



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.05.2013 Bulletin 2013/20

(51) Int Cl.:
G03G 15/00 (2006.01)

(21) Application number: **12184247.0**

(22) Date of filing: **13.09.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

- **Kawanabe, Motohiro**
Tokyo 143-8555 (JP)
- **Shikama, Takeshi**
Tokyo 143-8555 (JP)
- **Kinoshita, Izumi**
Tokyo 143-8555 (JP)
- **Yokoyama, Takuhei**
Tokyo 143-8555 (JP)
- **Miyazaki, Susumu**
Tokyo 143-8555 (JP)

(30) Priority: **16.09.2011 JP 2011202566**

(71) Applicant: **Ricoh Company, Ltd.**
Tokyo 143-8555 (JP)

(72) Inventors:
• **Miyadera, Tatsuya**
Tokyo 143-8555 (JP)

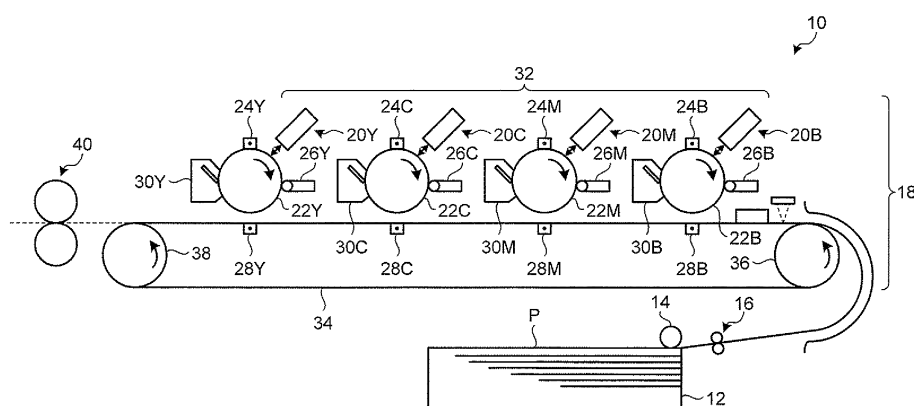
(74) Representative: **Schwabe - Sandmair - Marx**
Patentanwälte
Stuntzstraße 16
81677 München (DE)

(54) **Toner consumption calculator, image forming apparatus, and toner consumption calculation method**

(57) A toner consumption calculator includes a plurality of line memories; a processor that sequentially records image data including a plurality of pixels into the line memories and processes the image data by sequentially reading the image data from the line memories; an exposing unit that performs exposure in accordance with the processed image data and forms a latent image based on the image data on an image carrier; and a counter that sequentially reads the image data from the line memories and counts toner consumption of a target pixel

on the basis of light amounts of surrounding pixels of the target pixel. The processor reads the image data from the line memories L times (L is a natural number) and reads M pixels (M is a natural number) per line memory and per clock. M is equal to or larger than the number of surrounding pixels of the target pixel in a main-scanning direction. The counter reads the image data from the line memories L times, reads the M pixels per line memory and per clock, and counts the toner consumption of N target pixels ($N \leq M$).

FIG.1



Description

CROSS-REFERENCE TO RELATED APPLICATIONS

5 **[0001]** The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2011-202566 filed in Japan on September 16, 2011.

BACKGROUND OF THE INVENTION

10 1. Field of the Invention

[0002] The present invention relates to a toner consumption calculator, an image forming apparatus, and a toner consumption calculation method.

15 2. Description of the Related Art

[0003] In electrophotographic image forming apparatuses that perform exposure using laser diodes (LDs) or light emitting diode arrays (LEDAs), techniques have been known that calculate toner consumption taking into consideration an effect on a target pixel by light emitted to its surrounding pixels (e.g., refer to Japanese Patent No. 4396605). Such techniques can calculate the toner consumption with high accuracy.

[0004] Such related art techniques, however, require reference to much information of surrounding pixels to calculate the toner consumption with high accuracy, thereby increasing the number of built-in line memories and cost for the line memories.

25 **[0005]** In view of the above-mentioned facts, an object of the present invention is to provide a toner consumption calculator, an image forming apparatus, and a toner consumption calculation method that are capable of calculating toner consumption with high accuracy and at low cost.

SUMMARY OF THE INVENTION

30 **[0006]** According to an embodiment, there is provided a toner consumption calculator that includes a plurality of line memories; a processor that sequentially records image data including a plurality of pixels into the line memories and processes the image data by sequentially reading the image data from the line memories; an exposing unit that performs exposure in accordance with the processed image data and forms a latent image based on the image data on an image carrier; and a counter that sequentially reads the image data from the line memories and counts toner consumption of a target pixel on the basis of light amounts of surrounding pixels of the target pixel. The processor reads the image data from the line memories L times (L is a natural number) and reads M pixels (M is a natural number) per line memory and per clock. M is equal to or larger than the number of surrounding pixels of the target pixel in a main-scanning direction. The counter reads the image data from the line memories L times, reads the M pixels per line memory and per clock, and counts the toner consumption of N target pixels ($N \leq M$).

40 **[0007]** According to another embodiment, there is provided an image forming apparatus including the toner consumption calculator described above.

[0008] According to still another embodiment, there is provided a toner consumption calculation method that includes, by a processor, sequentially recording image data including a plurality of pixels into a plurality of line memories and processing the image data by sequentially reading the image data from the line memories; by an exposing unit, performing exposure in accordance with the processed image data and forming a latent image based on the image data on an image carrier; and by a counter, sequentially reading the image data from the line memories and counting toner consumption of a target pixel on the basis of light amounts of surrounding pixels of the target pixel. The processing includes reading the image data from the line memories L times (L is a natural number) and reading M pixels (M is a natural number) are read per line memory and per clock. M is equal to or larger than the number of surrounding pixels of the target pixel in a main-scanning direction. The sequentially reading and counting includes reading the image data from the line memories L times, reading the M pixels per line memory and per clock, and counting the toner consumption of N target pixels ($N \leq M$).

55 **[0009]** The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a schematic diagram illustrating an example of a mechanical structure of a printing apparatus of an embodiment of the present invention;
 FIG. 2 is a block diagram illustrating an example of a functional structure of the printing apparatus of the embodiment;
 FIG. 3 is an explanatory view illustrating an example of a technique performed by a counter of the embodiment to count toner consumption of a target pixel on the basis of light amounts of surrounding pixels of the target pixel;
 FIG. 4 is an explanatory view illustrating an example of the technique to count the toner consumption performed by the counter of the embodiment;
 FIG. 5 is a schematic diagram illustrating an example of a mechanical structure of a printing apparatus of a fifth modification; and
 FIG. 6 is a block diagram illustrating an exemplary hardware structure of the printing apparatuses of the embodiment and modifications.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Embodiments of a toner consumption calculator, an image forming apparatus, and a toner consumption calculation method according to the present invention are described in detail below with reference to the accompanying drawings. In the following embodiment, an example is described in which the image forming apparatus including the toner consumption calculator of the invention is applied to an electrophotographic printing apparatus. The invention, however, is not limited to being applied to the electrophotographic printing apparatus. The invention can be applied to any apparatuses that form images by electrophotography, such as electrophotographic copiers and multifunction peripherals (MFPs). The MFPs have at least two functions out of printing, copying, scanning, and facsimile functions.

[0012] FIG. 1 is a schematic diagram illustrating an example of a mechanical structure of a printing apparatus 10 of the embodiment.

[0013] As illustrated in FIG. 1, the printing apparatus 10 includes a paper cassette 12, a paper feeding roller 14, a separation roller pair 16, an image forming unit 18, and a fixing unit 40. FIG. 1 illustrates a so-called tandem printing apparatus in which image forming sections for respective colors are arranged along a conveying belt, which is described later. The printing apparatus, however, is not limited to the tandem type.

[0014] The paper cassette 12 houses a plurality of recording sheets in a stacked manner.

[0015] The paper feeding roller 14 abuts a recording sheet P located at the uppermost position in the paper cassette 12 and feeds the abutting recording sheet P.

[0016] The separation roller pair 16 sends the recording sheet P fed by the paper feeding roller 14 to the image forming unit 18. When two or more recording sheets are fed by the paper feeding roller 14, the separation roller pair 16 separates the recording sheet P from the other recording sheets by pushing back the other recording sheets, and sends only the recording sheet P to the image forming unit 18.

[0017] The image forming unit 18, which forms an image on the recording sheet P sent from the separation roller pair 16, includes image forming sections 20B, 20M, 20C, and 20Y, an LEDA head 32, a conveying belt 34, a driving roller 36, and a driven roller 38.

[0018] The image forming sections 20B, 20M, 20C, and 20Y are arranged in this order along the conveying belt 34 from an upstream side in a conveying direction of the conveying belt 34 conveying the recording sheet P sent from the separation roller pair 16.

[0019] The image forming section 20B includes a photosensitive drum 22B, and a charger 24B, a developing unit 26B, a transfer unit 28B, a photosensitive-element cleaner (not illustrated), and a neutralization device 30B that are arranged around the photosensitive drum 22B. The image forming section 20B and the LEDA head 32 form a black toner image on the photosensitive drum 22B by image forming processing (charging, exposing, developing, transfer, cleaning, and neutralization processes) on the photosensitive drum 22B.

[0020] Each of the image forming sections 20M, 20C, and 20Y has the same common components as the image forming section 20B. The image forming section 20M forms a magenta toner image by the image forming processing. The image forming section 20C forms a cyan toner image by the image forming processing. The image forming section 20Y forms a yellow toner image by the image forming processing. Therefore, the components of the image forming section 20B are primarily described below. The respective components of the image forming sections 20M, 20C, and 20Y are labeled with the respective suffixes of M, C, and Y instead of the suffix B for the components of the image forming section 20B, and descriptions thereof are omitted.

[0021] The photosensitive drum 22B (an example of an image carrier) is rotated by a driving motor (not illustrated).

[0022] First, in the charging process, the charger 24B uniformly charges in the dark an outer circumferential surface

of the photosensitive drum 22B that is being rotated.

[0023] Then, in the exposing process, the LEDA head 32 (an example of an exposing unit) exposes the outer circumferential surface of the photosensitive drum 22B that is being rotated by irradiation light corresponding to a black image to form a static latent image based on the black image on the photosensitive drum 22B. The LEDA head 32 exposes the outer circumferential surface of the photosensitive drum 22M by irradiation light corresponding to a magenta image, the outer circumferential surface of the photosensitive drum 22C by irradiation light corresponding to a cyan image, and the outer circumferential surface of the photosensitive drum 22Y by irradiation light corresponding to a yellow image.

[0024] Then, in the developing process, the developing unit 26B develops the static latent image formed on the photosensitive drum 22B by black toner to form a black toner image on the photosensitive drum 22B.

[0025] Then, in the transfer process, the transfer unit 28B transfers the black toner image formed on the photosensitive drum 22B onto the recording sheet P at a transfer position at which the photosensitive drum 22B and the recording sheet P conveyed by the conveying belt 34 make contact with each other. A slight amount of non-transferred toner remains on the photosensitive drum 22B after the toner image is transferred.

[0026] Then, in the cleaning process, the photosensitive-element cleaner removes the non-transferred toner remaining on the photosensitive drum 22B.

[0027] Lastly, in the neutralization process, the neutralization device 30B neutralizes potential remaining on the photosensitive drum 22B. Then, the image forming section 20B waits for the next image forming.

[0028] The conveying belt 34 is an endless belt wound and circulated between the driving roller 36 and the driven roller 38. The recording sheet P sent from the separation roller pair 16 adheres to the conveying belt 34 by static adhesion. The conveying belt 34 is moved in an endless manner by the driving roller 36 rotated by a driving motor (not illustrated) and conveys the recording sheet P adhering thereto to the image forming sections 20B, 20M, 20C, and 20Y in this order.

[0029] First, the image forming section 20B transfers the black toner image onto the recording sheet P conveyed by the conveying belt 34. Then, the image forming sections 20M, 20C, and 20Y transfer the magenta toner image, the cyan toner image, and the yellow toner image onto the recording sheet P in an overlapped manner, respectively. As a result, a full-color image is formed on the recording sheet P.

[0030] The fixing unit 40 fixes on the recording sheet P the full-color image formed through the image forming sections 20B, 20M, 20C, and 20Y, by heating and pressuring the recording sheet P having been removed from the conveying belt 34. The recording sheet P on which the image has been fixed is discharged outside the printing apparatus 10.

[0031] FIG. 2 is a block diagram illustrating an example of a functional structure of the printing apparatus 10 of the embodiment. As illustrated in FIG. 2, the printing apparatus 10 includes a controller 110, a page memory 120, an LEDA controller 130, and the LEDA head 32. The LEDA controller 130 and the LEDA head 32 are included in an example of the toner consumption calculator.

[0032] The controller 110 receives print data generated by a PC 50 (a printer driver installed in the PC 50) through a network (not illustrated). The print data is described by a page description language (PDL), for example. The controller 110 converts the received print data into image data (e.g., bit map data) composed of a plurality of pixels in the page memory 120 and transfers the converted image data to the LEDA controller 130 line by line.

[0033] The LEDA controller 130 causes the LEDA head 32 to emit light on the basis of the image data transferred from the controller 110 line by line so as to form the static latent image. That is, the LEDA controller 130 uses the image data transferred from the controller 110 as light-emitting data. The LEDA controller 130 includes a frequency converter 131, a line memory 133, an image processor 135, a skew correction unit 137, line memories 139-0 to 139-1 (I is a natural number of more than one), and a counter 141.

[0034] The controller 110 and the LEDA controller 130 differ from each other in their operation clock frequencies. Because of the difference, the frequency converter 131 sequentially records the image data transferred from the controller 110 line by line into the line memory 133, and performs frequency conversion by sequentially reading the recorded image data from the line memory 133 on the basis of the operation clock frequency of the LEDA controller 130, and transfers the converted data to the image processor 135 line by line.

[0035] The image processor 135 performs image processing on the image data transferred from the frequency converter 131 line by line and then transfers the processed data to the skew correction unit 137 line by line. Examples of the image processing include processing to add internal patterns and trimming. When processing that requires the line memory, such as jaggy correction, is performed as the image processing, for example, the LEDA controller 130 includes the line memory for the image processor 135.

[0036] The skew correction unit 137 (an example of a processor) sequentially records the image data transferred from the image processor 135 line by line into the line memories 139-0 to 139-1 (an example of a plurality of line memories), performs skew correction by sequentially reading the recorded data while switching read target line memories out of the line memories 139-0 to 139-1 in accordance with image positions, and transfer the corrected data to the LEDA head 32 line by line. In the embodiment, the skew correction unit 137 corrects a bow of the LEDA head 32 by the skew correction. The skew correction, however, is not limited to correction of the bow, and may correct a slant of an image caused by the image data.

[0037] A line period when the skew correction unit 137 reads the image data is one over L, i.e., $1/L$, (L is a natural number) of the line period when the skew correction unit 137 writes the image data. The skew correction unit 137 performs a resolution increasing process by continuously reading the same data from the line memory L times when reading the image data from the line memories 139-0 to 139-I. As a result of the resolution increasing process, the image data becomes high density image data having L times higher resolution in a sub-scanning direction than before being processed. In the embodiment, the skew correction unit 137 performs the resolution increasing process that doubles the resolution of the image data, i.e., $L = 2$, in the sub-scanning direction simultaneously together with the skew correction.

[0038] The skew correction unit 137 reads M pixels (M is a natural number) per line memory and per clock. In the embodiment, the skew correction unit 137 reads eight pixels per line memory and per clock, i.e., $M = 8$. As a result, the LEDA controller 130 can operate at a low clock frequency and can be achieved by a low cost application specific integrated circuit (ASIC).

[0039] Some LEDA heads 32 require, depending on their types, data arrangement conversion in accordance with wiring of the LEDA heads 32. In the case where the arrangement conversion needs to be done for all of the lines, the controller 130 has line memories for the arrangement conversion. Then, the image data after skew correction is subjected to the arrangement conversion in the line memories and transferred to the LEDA head 32 line by line.

[0040] The LEDA head 32 emits light on the basis of the image data transferred from the skew correction unit 137 line by line to form the static latent image. In the embodiment, since the skew correction unit 137 performs the resolution increasing process as described above, the LEDA head 32 can form a high density static latent image by increasing the resolution of the image data in the sub-scanning direction, thereby enabling precise tone control and positioning control to be achieved.

[0041] The counter 141 sequentially reads the image data from the line memories 139-0 to 139-I and counts the toner consumption of a target pixel on the basis of light amounts of surrounding pixels of the target pixel.

[0042] FIG. 3 is an explanatory view illustrating an example of a technique performed by the counter 141 of the embodiment to count toner consumption of a target pixel on the basis of light amounts of the surrounding pixels of the target pixel.

[0043] In the embodiment, the counter 141 reads the image data from consecutive five line memories out of the line memories 139-0 to 139-I, extracts from the read image data five pixels in a main-scanning direction and the sub-scanning direction each, and produces data of a 5×5 matrix including a target pixel A at the center of the matrix.

[0044] The counter 141 performs y conversion of density data on the produced data matrix in accordance with the characteristics of the LEDA head 32.

[0045] Then, the counter 141 sets weighting coefficients for the respective pixels included in the produced data matrix and calculates a total light amount of the target pixel A using the weighting coefficients. Specifically, the counter 141 calculates the total light amount of the target pixel A using Formula (1). The weighting coefficients of reference pixels located at symmetric positions with respect to the target pixel A in the data matrix are set to be equal to each other.

$$\begin{aligned} \text{Total light amount of target pixel A} = & A * \text{main} + (C + \\ & G) * \text{ref1_1} + (E + I) * \text{ref1_2} + (B + D + F + H) * \text{ref1_3} + (L + \\ & T) * \text{ref2_1} + (P + X) * \text{ref2_2} + (K + M + S + U) * \text{ref2_3} + (O + Q + W \\ & + Y) * \text{ref2_4} + (J + N + R + V) * \text{ref2_5} \end{aligned} \quad (1)$$

[0046] Subsequently, the counter 141 performs a saturation process. The reason why the saturation process is performed is that the toner consumption in development (also referred to as a toner development amount) is proportional to an amount of light used for exposing the photosensitive drum 22 and saturates at a certain light amount (the upper limit value of the toner development amount), beyond which no toner is used for development. Specifically, the counter 141 sets a corresponding value of the toner consumption of the target pixel A to be equal to the total light amount of the target pixel A when the total light amount of the target pixel A $\leq$ the upper limit value, while the counter 141 sets the corresponding value of the toner consumption of the target pixel A to be equal to the upper limit value when the total light amount of the target pixel A $>$ the upper limit value.

[0047] Then, the counter 141 subtracts a constant offset value from the corresponding value of the toner consumption of the target pixel A in order to approximate the corresponding value of the toner consumption of the target pixel A to the actual toner consumption. When the actual toner consumption (a value after subtraction of the offset value) is negative, the actual toner consumption is set to zero.

[0048] The counter 141 calculates the total toner consumption consumed in the development of certain image data by performing the above-describe processes on all of the pixels of the certain image data. A surrounding pixel located off the image region is processed as the pixel having a light amount of zero.

[0049] In the embodiment, the line period when the counter 141 reads the image data is one over L, i.e., $1/L$, (in the embodiment, $L = 2$) of the line period when the skew correction unit 137 writes the image data. That is, the counter 141 also continuously reads the same image data twice from the line memories 139-0 to 139-I.

[0050] The counter 141 reads M pixels (in the embodiment, $M = 8$) per line memory and per clock from consecutive line memories corresponding to the number of surrounding pixels in the sub-scanning direction (in the embodiment, five consecutive line memories) out of the line memories 139-0 to 139-I, and counts the toner consumption of N ($N \leq M$) target pixels out of the M target pixels. In the embodiment, the counter 141 counts the toner consumption of four target pixels per line memory and per clock, i.e., $N = 4$. In addition, M needs to be equal to or larger than the number of surrounding pixels in the main-scanning direction. In the embodiment, M needs to be equal to or larger than five because the toner consumption of the target pixel is counted on the basis of the generated data of a 5×5 matrix including the target pixel at the center of the matrix.

[0051] Thus, in the embodiment, the counter 141 counts the toner consumption of four target pixels out of eight target pixels per clock when reading the same image data from five consecutive line memories out of the line memories 139-0 to 139-I in the first reading, and counts the other four target pixels out of the eight target pixels per clock when reading the same image data in the second reading.

[0052] FIG. 4 is an explanatory view illustrating an example of the technique to count the toner consumption performed by the counter 141 of the embodiment. In the example illustrated in FIG. 4, the pixels are read from the center line memory out of the consecutive five line memories and the reading of pixels from the other line memories is not illustrated.

[0053] As illustrated in FIG. 4, the counter 141 reads from the center line memory pixel 1 to pixel 8 at the first clock, pixel 9 to pixel 19 at the second clock, pixel 17 to pixel 24 at the third clock, and pixel 25 to pixel 32 at the fourth clock when reading the image data in the first reading. Because the pixels corresponding to two addresses (two clocks) are necessary for counting the toner consumption of the target pixel, the counter 141 causes a delay circuit (e.g., a flip-flop, not illustrated) to hold the read eight pixels for each clock, and then, after one clock delay, the counter 141 counts the toner consumption of the target pixels.

[0054] First, the counter 141 counts the toner consumption of the four target pixels of pixel -1, pixel 0, pixel 1, and pixel 2 by the method described with reference to FIG. 3, at the second clock. In the example illustrated in FIG. 4, pixel -1 and pixel 0 are not illustrated. Then, the counter 141 counts the toner consumption of the four target pixels of pixel 7, pixel 8, pixel 9, and pixel 10 at the third clock, and counts the toner consumption of the four target pixels of pixel 15, pixel 16, pixel 17, and pixel 18 at the fourth clock. The counter 141 continues to count the toner consumption of the target pixels in the same manner as described above.

[0055] Thus, when having completed the first reading of the image data from the center line memory, the counter 141 has completed the count of the toner consumption of half of the target pixels.

[0056] In the second reading of the image data, the counter 141 reads from the center line memory pixel 1 to pixel 8 at the $(n + 1)$ th clock, pixel 9 to pixel 16 at the $(n + 2)$ th clock, pixel 17 to pixel 24 at the $(n + 3)$ th clock, and pixel 25 to pixel 32 at the $(n + 4)$ th clock. In the same manner as the first reading of the image data, the counter 141 causes the delay circuit (not illustrated) to hold the read eight pixels for each clock, and then, after one clock delay, the counter 141 counts the toner consumption of the target pixels.

[0057] First, the counter 141 counts the toner consumption of the four target pixels of pixel 3, pixel 4, pixel 5, and pixel 6 by the method described with reference to FIG. 3, at the $(n + 2)$ th clock. Then, the counter 141 counts the toner consumption of the four target pixels of pixel 11, pixel 12, pixel 13, and pixel 14 at the $(n + 3)$ th clock, and counts the toner consumption of the four target pixels of pixel 19, pixel 20, pixel 21, and pixel 22 at the $(n + 4)$ th clock. The counter 141 continues to count the toner consumption of the target pixels in the same manner as described above.

[0058] Thus, when having completed the second reading of the image data from the center line memory, the counter 141 counts the toner consumption of the target pixels having not been counted in the first reading of the image data, and calculates the toner consumption of the image data recorded in the center line memory.

[0059] As described above, according to the embodiment, the line memories used for the skew correction and the line memories used for counting the toner consumption are in common with each other as described above, thereby enabling the number of line memories to be reduced and the toner consumption to be calculated with high accuracy and at low cost.

[0060] Particularly in the embodiment, the number of pixels whose toner consumption is counted per clock is equal to or less than the number of pixels processed (read) in the skew correction per clock. As a result, deterioration of performance such as a drop in processing speed of the skew correction due to the counting of the toner consumption can also be prevented.

[0061] In the embodiment, the number of pixels (the value of N) whose toner consumption is counted per clock can be decreased by increasing the value of L, thereby enabling the number of circuits in the ASIC used for the LEDA controller 130 to be reduced. For example, when the value of L is four and the value of M is eight, the number of pixels (the value of N) whose toner consumption is counted per clock is two. From the viewpoint of reducing the number of circuits in the ASIC, at least one of L and M is preferably a power of two.

[0062] The line memory used in the embodiment may be any of a static random access memory (SRAM), a flip-flop,

and a non volatile RAM (NVRAM).

Modifications

[0063] The invention is not limited to the above-described embodiment and various modifications can be made.

First Modification

[0064] In the above-described embodiment, the counter 141 does not count the toner consumption in the order of exposures performed by the LEDA head 32 on the basis of pixels. Therefore, when the printing apparatus 10 makes an emergency stop and the image data transfer to the skew correction unit 137 is discontinued, errors will occur in the count of the toner consumption if the processes are immediately stopped.

[0065] In order to address such a situation, the following manner may be adopted in the embodiment when the image data transfer is discontinued. The skew correction unit 137 reads, L times, the image data corresponding to one line being read at the time of occurrence of the discontinuation, and thereafter discontinues the reading process. The LEDA head 32 performs exposure for the image data corresponding to the one line read by the skew correction unit 137, and thereafter discontinues the exposure process. The counter 141 counts the toner consumption of all the target pixels of the image data corresponding to the one line being read by the skew correction unit 137 at the time of occurrence of the discontinuation, and thereafter discontinues the counting of the toner consumption.

[0066] This manner enables the pixel exposed by the LEDA head 32 and the pixel whose toner consumption is counted by the counter 141 to coincide with each other even when the printing apparatus 10 makes an emergency stop and the image data transfer to the skew correction unit 137 is discontinued. As a result, the occurrence of errors in the count of the toner consumption can be prevented.

Second Modification

[0067] For example, when the value of L is changed in accordance with print setting in the embodiment to thereby satisfy $N > M/L$, after completing the counting of the toner consumption of all the target pixels of the image data corresponding to one line, the counter 141 may stop counting the toner consumption until starting to count the toner consumption of the target pixel of the image data of the next line. Alternatively, the counter 141 may continue to count the toner consumption of the target pixels of the image data corresponding to one line and serving as the counting target of the toner consumption until completing the reading, L times, of the image data corresponding to certain lines used for counting the image data corresponding to the one line, and may reduce the value of the counted toner consumption in accordance with a ratio between N and M/L after completing the reading of image data corresponding to certain lines L times.

[0068] For example, when the value of L is changed from 2 to 4, the counter 141 counts the toner consumption by setting the value of L to 2, which is the smaller one, and the value of N to 4. In this case, the counter 141 counts the toner consumption in the manner described in the embodiment when $L = 2$. On the other hand, when $L = 4$, the counter 141 completes the counting of the toner consumption of all the target pixels of the image data corresponding to one line after counting the toner consumption of the image data read at the second reading. Therefore, the counter 141 may stop counting the toner consumption of the image data read at the third and fourth reading. Alternatively, when $L = 4$, the counter 141 may count the image data up to one read at the fourth reading and divide the counting result by 2 after completing the counting.

Third Modification

[0069] In the embodiment, the line memories used for the skew correction are used for counting the toner consumption because it is preferable for counting the toner consumption with high accuracy to form a large data matrix using a large number of line memories. The line memories used for counting the toner consumption are not limited to the line memories used for the skew correction.

[0070] For example, the line memory 133 used by the frequency converter 131 for frequency conversion or the line memory used by the image processor 135 for image processing may be used for counting the toner consumption. Examples of the image processing include processing to correct characteristics of the image data, jaggy correction processing, and dithering.

[0071] As another example, a line memory used by a frequency converter (not illustrated) that converts a transfer frequency of the image data based on the operation frequency of the LEDA controller 130 into that based on the operation frequency of the LEDA head 32 may be used for counting the toner consumption. As still another example, a line memory used by an arrangement converter (not illustrated) that converts the data arrangement in accordance with the type of

LEDA head 32 may be used for counting the toner consumption. As still another example, a line memory used by a period variation correction unit (not illustrated) that corrects the period variation in the sub-scanning direction may be used for counting the toner consumption.

5 Fourth Modification

[0072] In the embodiment, the LEDA head 32 serves as an exposing mechanism. The exposing mechanism may be achieved by a laser diode (LD) head or an organic electroluminescence (EL) head.

10 Fifth Modification

[0073] In the embodiment, each image forming unit forms an image directly on the recording sheet. Each image forming unit may form an image on an intermediate transfer belt and the image may be transferred to the recording sheet from the intermediate transfer belt. In the following description, differences from the embodiment are primarily described. The same name and reference numeral of the embodiment are given to the element having the same function, and description thereof is not repeated.

[0074] FIG. 5 is a schematic diagram illustrating an example of a mechanical structure of a printing apparatus 210 of a fifth modification. As illustrated in FIG. 5, the printing apparatus 210 differs from that of the embodiment in that an image forming unit 318 includes an intermediate transfer belt 334, a driving roller 336, and a driven roller 338 instead of the conveying belt 34, the driving roller 36, and the driven roller 38, and further includes a secondary transfer roller 339.

[0075] The intermediate transfer belt 334 is an endless belt wound and circulated between the driving roller 336 and the driven roller 338. The intermediate transfer belt 334 is moved to the image forming sections 20B, 20M, 20C, and 20Y in this order in an endless manner by the driving roller 336 rotated by a driving motor (not illustrated).

[0076] First, the image forming section 20B transfers a black toner image onto the intermediate transfer belt 334. Then, the image forming sections 20M, 20C, and 20Y transfer a magenta toner image, a cyan toner image and a yellow toner image onto the intermediate transfer belt 334 in an overlapped manner, respectively. As a result, a full-color image is formed on the intermediate transfer belt 334.

[0077] The recording sheet P is sent from the separation roller pair 16 onto the intermediate transfer belt 334 on which the image has been formed. The image is transferred from the intermediate transfer belt 334 to the recording sheet P at a secondary transfer position at which the intermediate transfer belt 334 and the recording sheet P make contact with each other.

[0078] The secondary transfer roller 339 is disposed at the secondary transfer position. The secondary transfer roller 339 presses the recording sheet P to the intermediate transfer belt 334 at the secondary transfer position. This pressing contact enhances transfer efficiency. The secondary transfer roller 339 makes close contact with the intermediate transfer belt 334, and thus has no contact-removal mechanism.

Hardware Structure

[0079] FIG. 6 is a block diagram illustrating an exemplary hardware structure of the printing apparatuses of the embodiment and the modifications. As illustrated in FIG. 6, the printing apparatus of the embodiment and each modification includes a controller 910 and an engine unit (or engine) 960 that are coupled through a peripheral component interconnect (PCI) bus. The controller 910 controls the whole of the multifunction peripheral, drawing, communications, and input from an operation display 920. The engine 960 is a printer engine that can be coupled with the PCI bus. Examples of the engine 960 include a monochrome plotter, a single-drum color plotter, a four-drum color plotter, a scanner and a facsimile unit. The engine 960 includes a section for image processing such as error diffusion and gamma conversion in addition to the so-called engine such as the plotter.

[0080] The controller 910 includes a CPU 911, a north bridge (NB) 913, a system memory (MEM-P) 912, a south bridge (SB) 914, a local memory (MEM-C) 917, an ASIC 916, and a hard disk drive (HDD) 918. The north bridge (NB) 913 and the ASIC 916 are coupled through an accelerated graphics port (AGP) bus 915. The MEM-P 912 includes a ROM 912a and a RAM 912b.

[0081] The CPU 911 controls the whole of the multifunction peripheral, and includes a chipset composed of the NB 913, the MEM-P 912, and the SB 914. The multifunction peripheral is coupled with other apparatuses through the chipset.

[0082] The NB 913 is a bridge for coupling the CPU 911 with the MEM-P 912, the SB 914, and the AGP bus 915. The NB 913 includes a memory controller for controlling writing to the MEM-P 912, a PCI master, and an AGP target.

[0083] The MEM-P 912 is a system memory used for a storage memory of programs and data, a development memory of programs and data, and a drawing memory of a printer, for example. The MEM-P 912 is composed of the ROM 912a and the RAM 912b. The ROM 912a is a read only memory used for a storage memory of programs and data. The RAM 912b is a writable and readable memory used for a development memory of programs and data and a drawing memory

of a printer, for example.

[0084] The SB 914 is a bridge for coupling the NB 913 with PCI devices and peripheral devices. The SB 914 and the NB 913 are coupled through the PCI bus, with which a network interface (I/F) section, for example, is coupled.

[0085] The ASIC 916 is an integrated circuit (IC) for image processing and includes hardware for image processing. The ASIC 916 serves as a bridge for coupling the AGP bus 915, the PCI bus, the HDD 918, and the MEM-C 917 with itself. The ASIC 916 is composed of the PCI target, the AGP master, an arbiter (ARB) that is the core of the ASIC 916, a memory controller that controls the MEM-C 917, a plurality of direct memory access controllers (DMACs) that carry out image data rotation with hardware logics, and a PCI unit that carries out data transfer between itself and the engine 960 through the PCI bus. The ASIC 916 is coupled with a universal serial bus (USB) 940, and an Institute of Electrical and Electronics Engineers 1394 (IEEE1394) interface 950 through the PCI bus. The operation display 920 is directly connected to the ASIC 916.

[0086] The MEM-C 917 is a local memory used for a copying image buffer and a code buffer. The HDD 918 is a storage for storing image data, programs, font data, and forms.

[0087] The AGP bus 915 is a bus interface for a graphic accelerator card and has been developed to carry out graphic processing with high speed. The AGP bus 915 allows a graphic accelerator card to operate at high speed with direct access to the MEM-P 912 at a high throughput.

[0088] According to the invention, the toner consumption can be calculated with high accuracy and at low cost.

[0089] Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

Claims

1. A toner consumption calculator, comprising:

a plurality of line memories;

a processor that sequentially records image data including a plurality of pixels into the line memories and processes the image data by sequentially reading the image data from the line memories;

an exposing unit that performs exposure in accordance with the processed image data and forms a latent image based on the image data on an image carrier; and

a counter that sequentially reads the image data from the line memories and counts toner consumption of a target pixel on the basis of light amounts of surrounding pixels of the target pixel, wherein

the processor reads the image data from the line memories L times (L is a natural number) and reads M pixels (M is a natural number) per line memory and per clock, M being equal to or larger than the number of surrounding pixels of the target pixel in a main-scanning direction, and

the counter reads the image data from the line memories L times, reads the M pixels per line memory and per clock, and counts the toner consumption of N target pixels ($N \leq M$).

2. The toner consumption calculator according to claim 1, wherein the processor performs skew correction that corrects a bow of the exposing unit.

3. The toner consumption calculator according to claim 1, wherein the processor performs skew correction that corrects a slant of an image caused by the image data.

4. The toner consumption calculator according to any one of claims 1 to 3, wherein when transfer of the image data is discontinued, the processor reads, L times, the image data corresponding to one line being read at a time of occurrence of the discontinuation, and thereafter discontinues the reading,

the exposing unit performs exposure for the image data corresponding to the one line read by the processor, and thereafter discontinues the exposure, and

the counter counts the toner consumption of all the target pixels of the image data corresponding to the one line being read by the processor at the time of occurrence of the discontinuation, and thereafter discontinues the counting of the toner consumption.

5. The toner consumption calculator according to any one of claims 1 to 4, wherein when $N > M/L$, after completing the counting of the toner consumption of all the target pixels of the image data corresponding to one line, the counter stops counting the toner consumption until starting to count the toner consumption of the target pixel of the image data of the next line.

6. The toner consumption calculator according to any one of claims 1 to 4, wherein when $N > M/L$, the counter continues to count the toner consumption of the target pixel of the image data corresponding to one line and serving as a counting target of the toner consumption until completing reading, L times, of the image data corresponding to certain lines used for counting the image data corresponding to the one line, and reduces a value of the counted toner consumption in accordance with a ratio between N and M/L after completing the reading of the image data corresponding to the certain lines L times.
7. The toner consumption calculator according to any one of claims 1 to 6, wherein at least one of L and M is a power of two.
8. An image forming apparatus, comprising the toner consumption calculator according to any one of claims 1 to 7.
9. A toner consumption calculation method, comprising:
 - by a processor, sequentially recording image data including a plurality of pixels into a plurality of line memories and processing the image data by sequentially reading the image data from the line memories;
 - by an exposing unit, performing exposure in accordance with the processed image data and forming a latent image based on the image data on an image carrier; and
 - by a counter, sequentially reading the image data from the line memories and counting toner consumption of a target pixel on the basis of light amounts of surrounding pixels of the target pixel, wherein the processing includes reading the image data from the line memories L times (L is a natural number) and reading M pixels (M is a natural number) are read per line memory and per clock, M being equal to or larger than the number of surrounding pixels of the target pixel in a main-scanning direction, and the sequentially reading and counting includes reading the image data from the line memories L times, reading the M pixels per line memory and per clock, and counting the toner consumption of N target pixels ($N \leq M$).

FIG.1

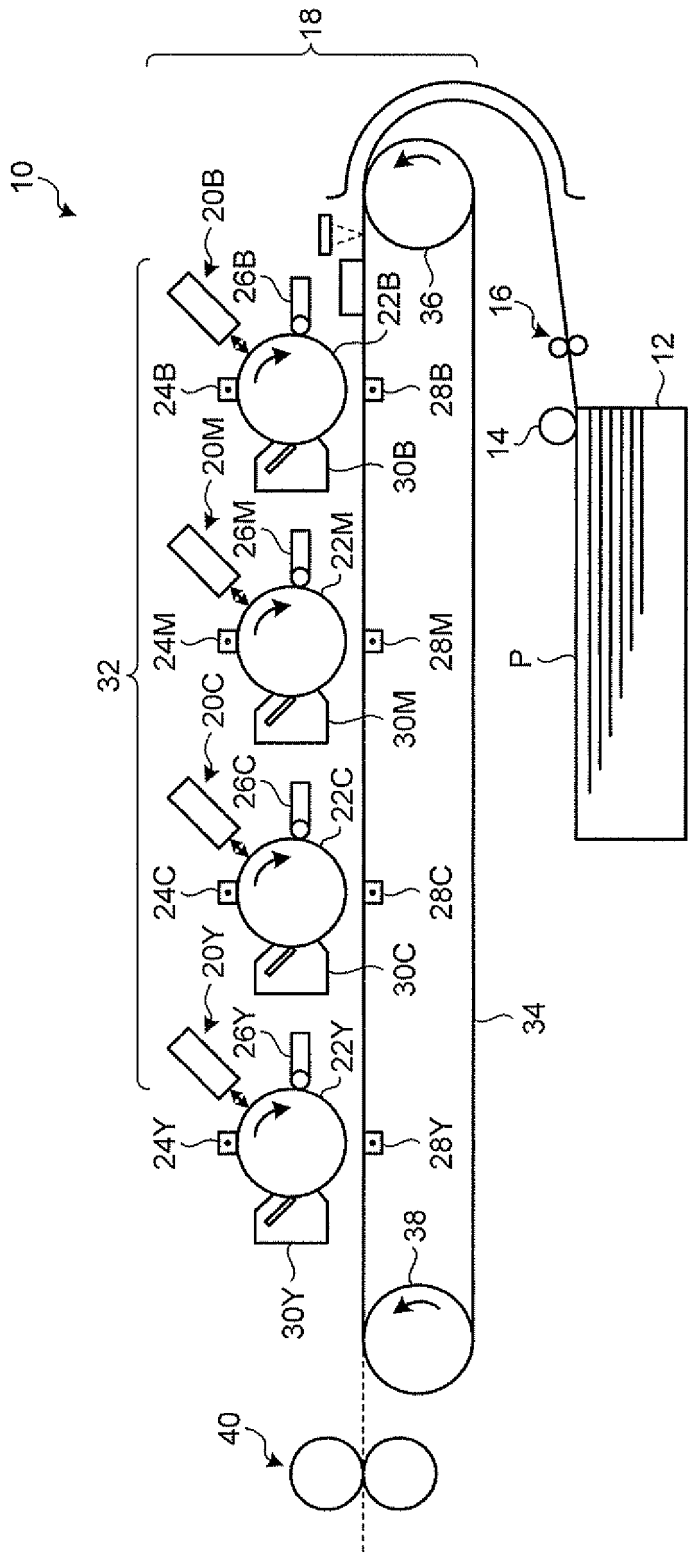


FIG.2

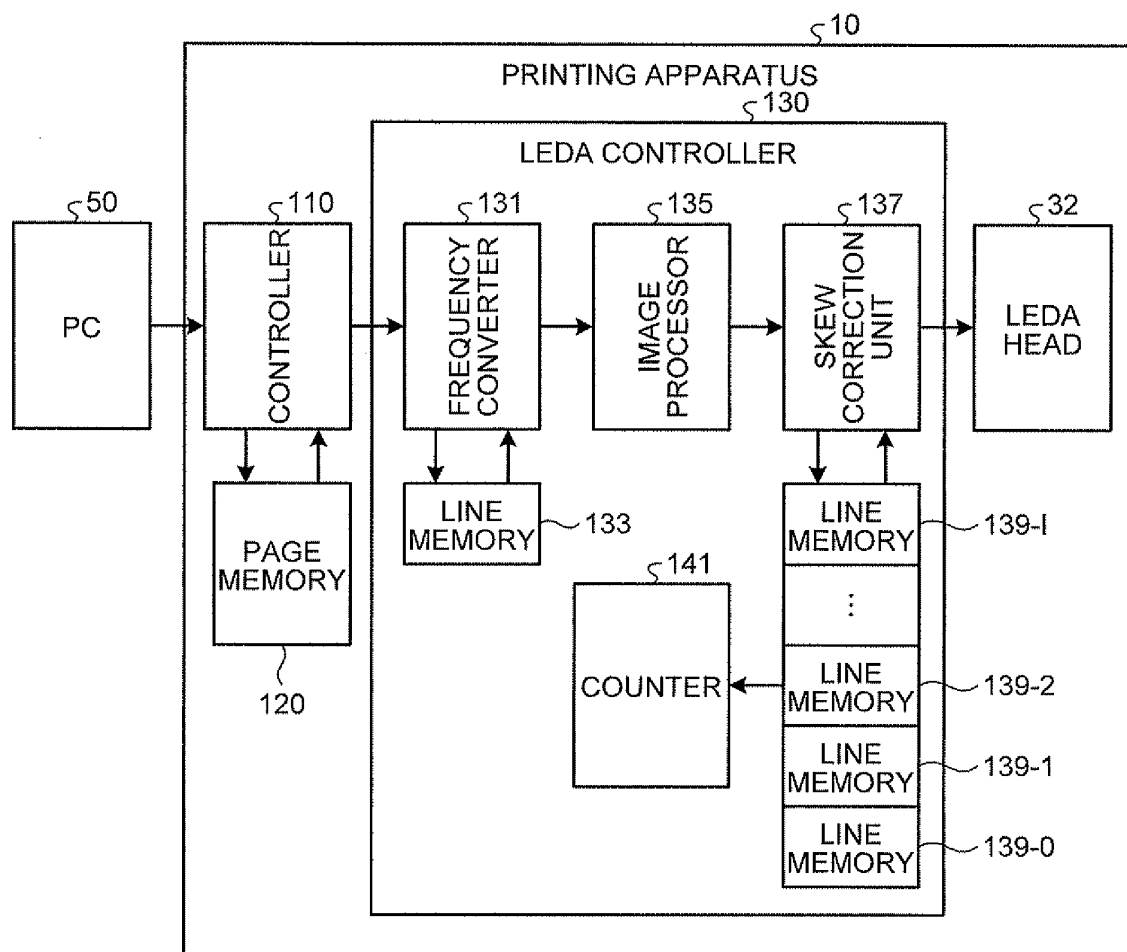


FIG.3

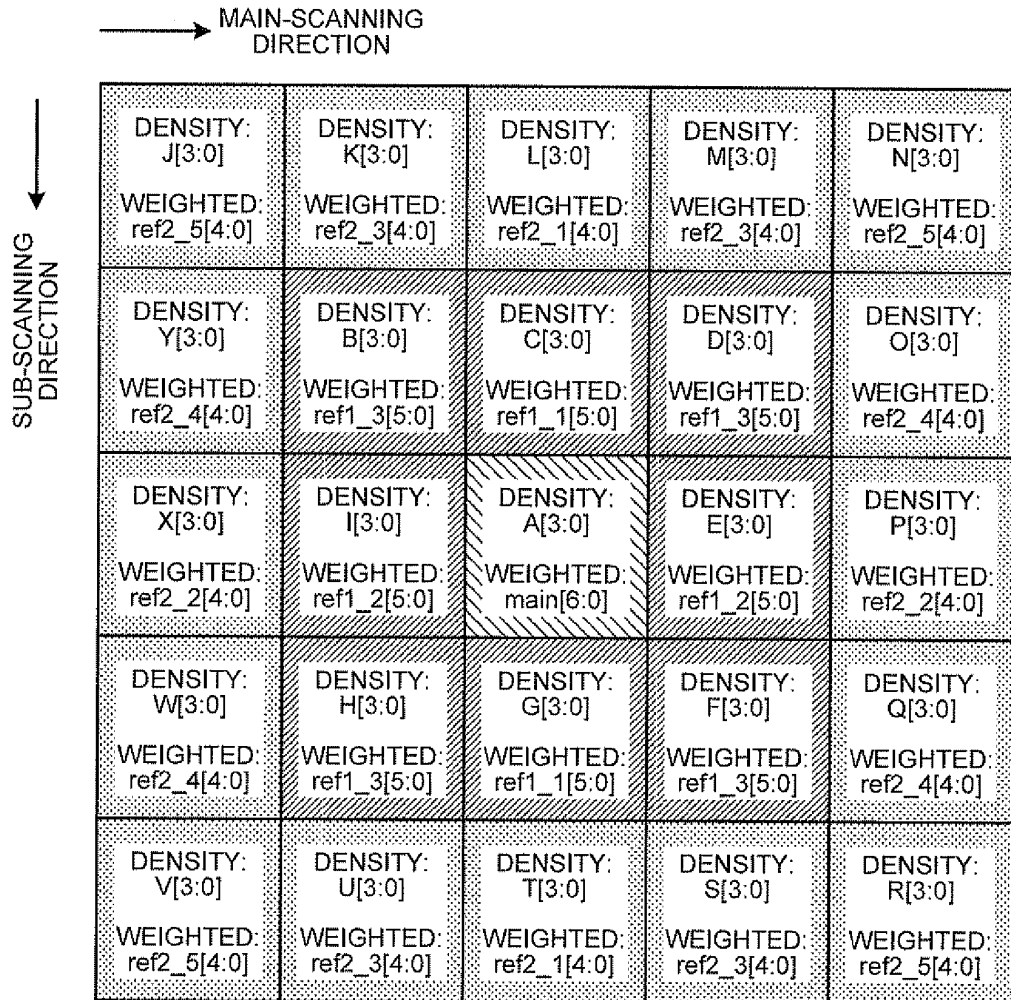
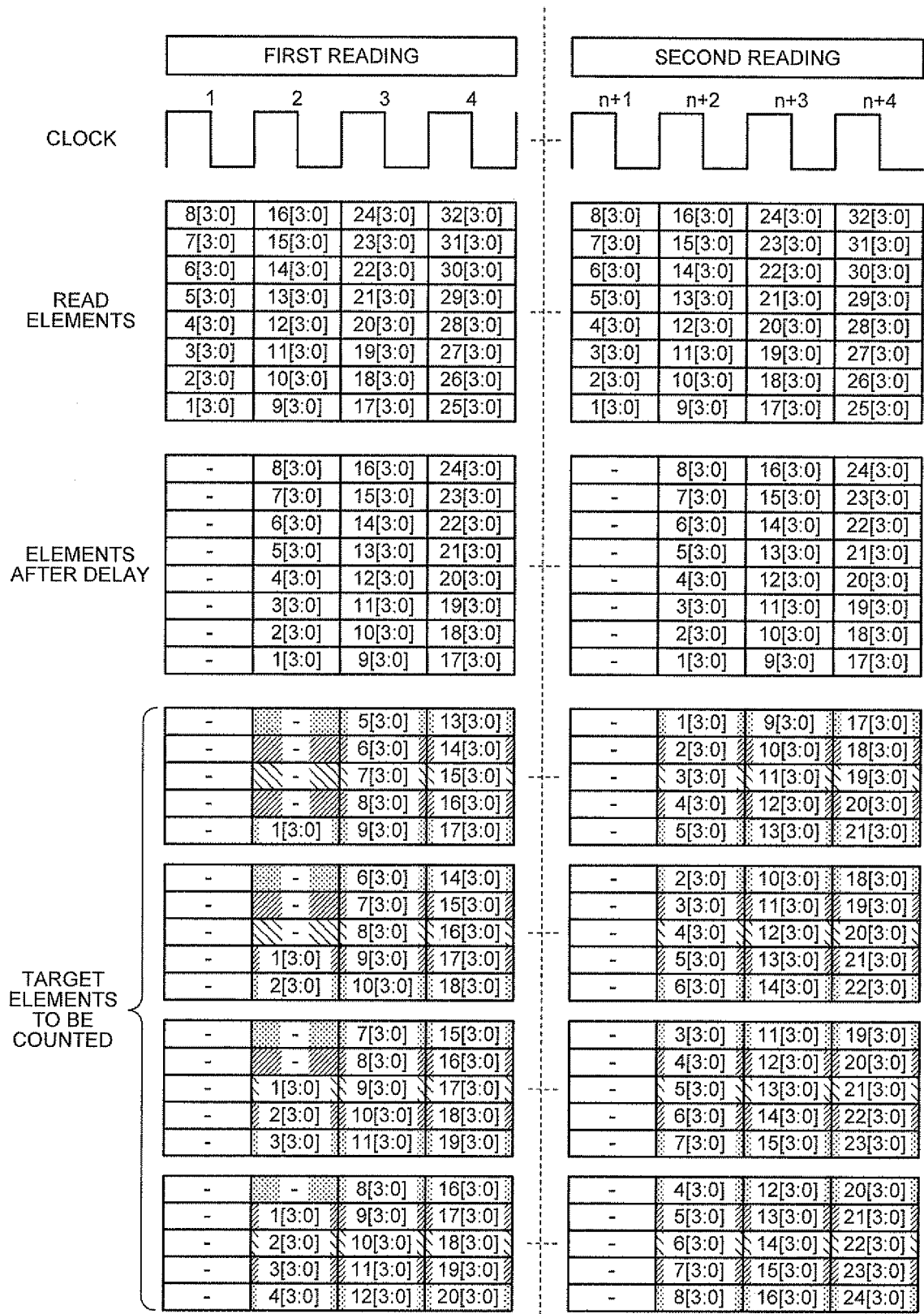


FIG.4



F/G.5

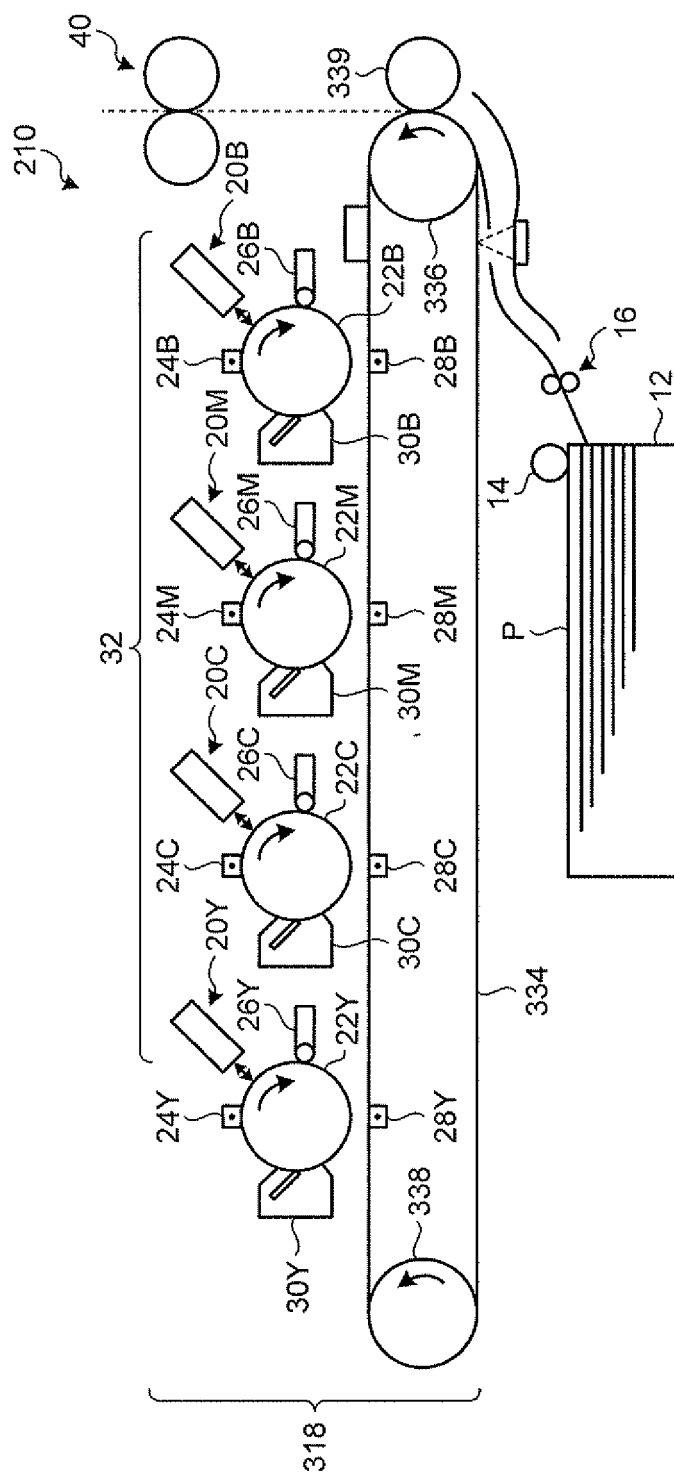
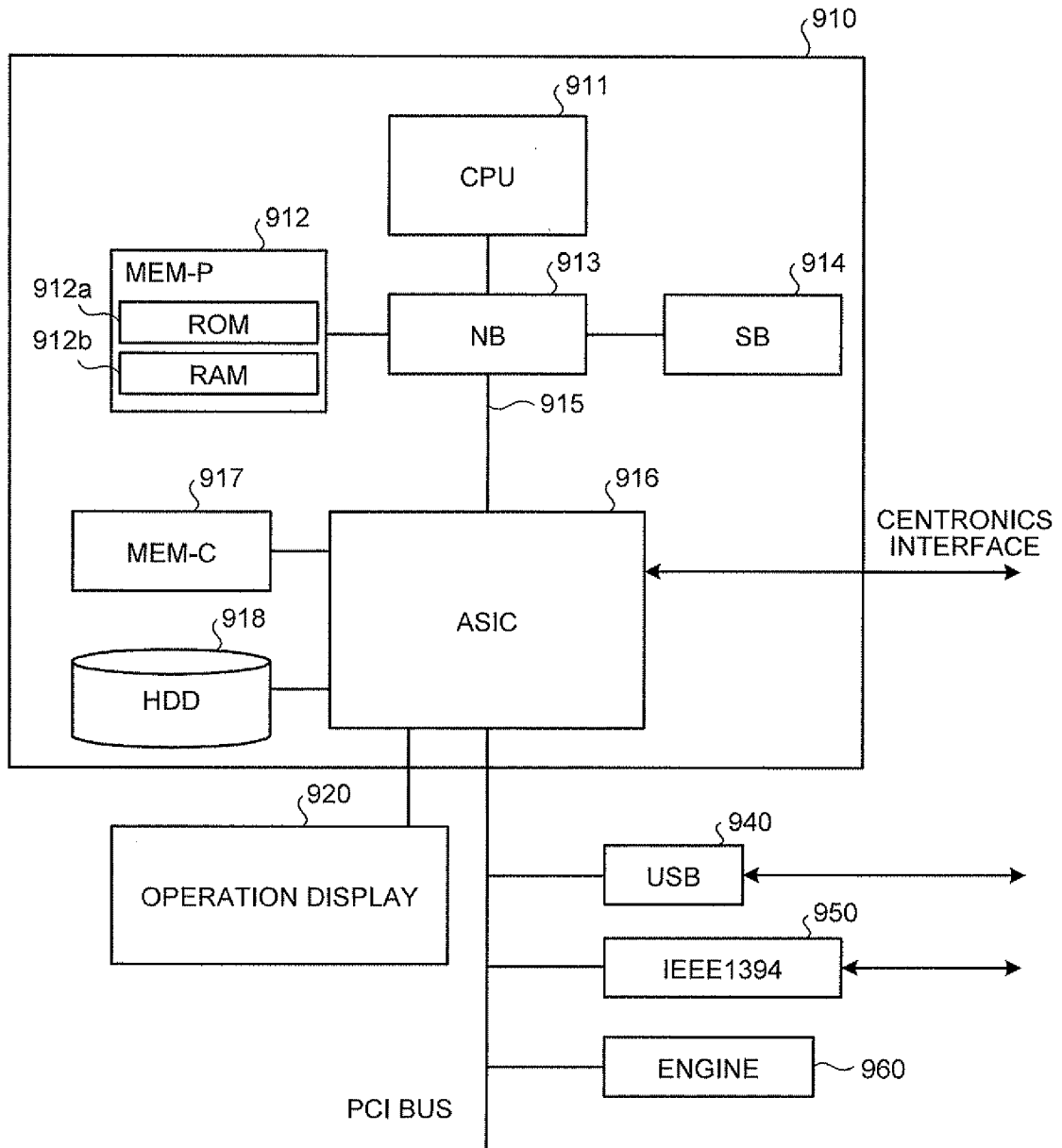


FIG.6



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2011202566 A [0001]
- JP 4396605 B [0003]