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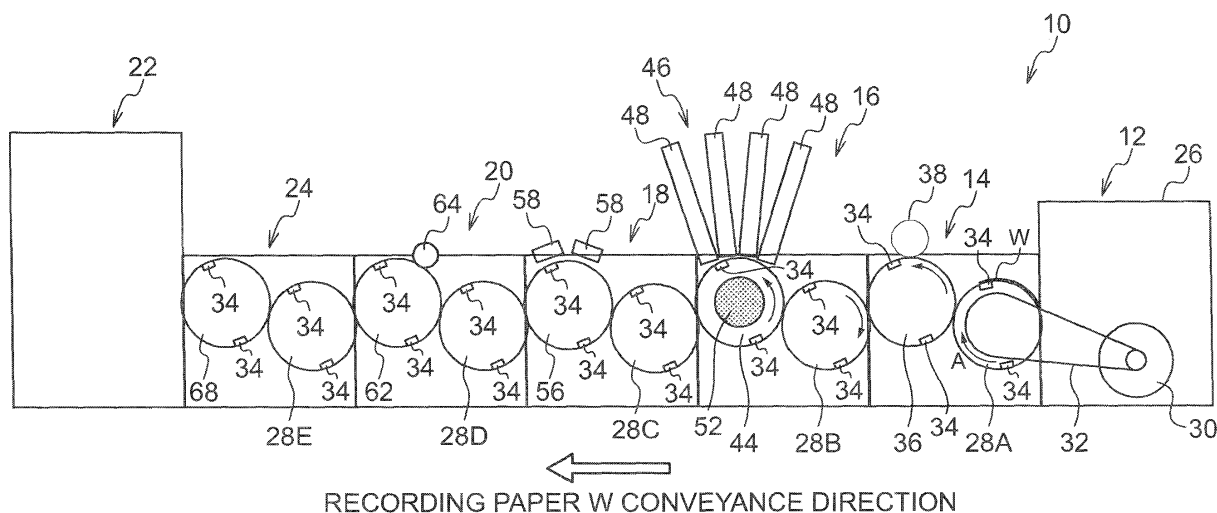
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(54) **Speed calculation device, speed estimation device, image forming device, and program**

(57) A speed calculation device is provided. The generation component generates a plurality of pulse signals with different phases in accordance with rotation of a rotating body. The detection component detects rises and falls of respective pulses of the plurality of pulse signals generated by the generation component. The duration calculation component, each time a rise or fall is detected

by the detection component, calculates a total duration of a pre-specified number of durations representing detection intervals of rises or falls detected prior to the rise or fall currently detected by the detection component. The speed calculation component calculates a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals.

FIG.1



Description**BACKGROUND**5 **Technical Field of the Invention**

[0001] The present invention relates to a speed calculation device, a speed estimation device, an image forming device, and a program.

10 **Related Art**

[0002] Heretofore, an image recording device has been known (see, for example, Japanese Patent Application Laid-Open (JP-A) No. 2007-301768) that includes: a recording head provided along a pre-specified conveyance direction; a conveyance component that includes a rotary driving component with a rotation reference point and conveys a recording medium to the recording head by rotary driving of the rotary driving component; a detection component that detects the rotation reference point of the rotary driving component during conveyance of the recording medium by the conveyance component and that detects a rotary speed at a rotation angle from the rotation reference point; and a control component that includes a memory component, which memorizes a print clock correction amount corresponding with the conveyance speed of the recording medium, which varies in accordance with eccentricity of the rotary driving component, and that generates a print clock on the basis of the print clock correction amount memorized in the memory component and a print clock modification amount, which is calculated from an amount of variation of the angular speed detected by the detection component relative to a pre-specified reference angular speed.

[0003] Also heretofore, a timing pulse generation device has been known (see, for example, JP-A No. 2007-145008) that is installed at a droplet ejection device which, in a fixed speed region and an acceleration/deceleration region of a moving body with a droplet ejection component, realizes ejections of droplets by the droplet ejection component. This timing pulse generation device includes: a first pulse signal component that generates a first pulse signal with a period corresponding to a movement speed of the moving body; a prediction component that measures the period of the first pulse signal generated by the first pulse generation component to obtain a measured period and uses the measured period to predict a period of the first pulse signal that the first pulse generation component will generate thereafter; a second pulse generation component, including a period division component, that generates a second pulse signal with a period for which the predicted period is divided up; and a signal generation component that generates ejection timing signals, which determine droplet ejection times of the droplet ejection component, on the basis of the second pulse signal.

35 **SUMMARY OF THE INVENTION**

[0004] The present invention has been made in view of the above circumstances and provides a speed calculation device, an speed estimation device, an image forming device, and a program.

[0005] A first aspect of the present invention is a speed calculation device including: a generation component that generates a plurality of pulse signals with different phases in accordance with rotation of a rotating body; a detection component that detects rises and falls of respective pulses of the plurality of pulse signals generated by the generation component; a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified number of durations representing detection intervals of rises or falls detected prior to the rise or fall currently detected by the detection component; and a speed calculation component that calculates a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals.

[0006] A second aspect of the present invention includes: a generation component that generates a plurality of pulse signals with different phases in accordance with rotation of a rotating body; a detection component that detects rises and falls of respective pulses of the plurality of pulse signals generated by the generation component; a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified first number of durations representing detection intervals of rises or falls detected prior to the rise or fall currently detected by the detection component; and a speed calculation component that calculates a speed relating to rotation of the rotating body on the basis of a pre-specified second number of the total durations calculated by the duration calculation component and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals.

[0007] A third aspect of the present invention is a speed calculation device including: a generation component that generates a plurality of pulse signals with different phases in accordance with rotation of a rotating body; a detection component that detects rises and falls of respective pulses of the plurality of pulse signals generated by the generation component; a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified first number of durations representing detection intervals of rises or falls

detected prior to the rise or fall currently detected by the detection component; and a speed calculation component that includes a speed detection section that detects a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals, and a speed calculation section that, after a pre-specified number of speeds have been detected by the speed detection section, calculates by estimation, on the basis of a pre-specified second number of the speeds relating to rotation of the rotating body that have been detected by the speed detection section, the speed relating to rotation of the rotating body that is to be detected subsequent to the speed relating to rotation of the rotating body currently detected by the speed detection section.

[0008] A fourth aspect of the present invention is an image forming device including: the speed calculation device of any one of the first aspect to the third aspect; a recording head at which a plurality of image forming elements are disposed, the image forming elements forming dots, which respectively constitute an image, at a predetermined surface synchronously with a clock signal; a period calculation component that calculates a period of the clock signal on the basis of the speed calculated by the speed calculation device and a peripheral face of the rotating body, and a distance between neighboring dots; wherein the rotating body of the rotation speed detection device rotates with the peripheral face opposing the plurality of image forming elements in a state in which a recording medium is retained at the peripheral face, such that the image is formed at the recording medium by the plurality of image forming elements.

[0009] A fifth aspect of the present invention is a program for causing a computer to function as: a detection component that detects rises and falls of respective pulses of a plurality of pulse signals generated by a generation component, which generates the plurality of pulse signals with different phases in accordance with rotation of a rotating body; a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified number of durations representing detection intervals of rises or falls detected by the detection component prior to the current rise or fall detected by the detection component; and a speed calculation component that calculates a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals.

[0010] A sixth aspect of the present invention is a program for causing a computer to function as: a detection component that detects rises and falls of respective pulses of a plurality of pulse signals generated by a generation component, which generates the plurality of pulse signals with different phases in accordance with rotation of a rotating body; a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified first number of durations representing detection intervals of rises or falls detected by the detection component prior to the current rise or fall detected by the detection component; and a speed calculation component that calculates a speed relating to rotation of the rotating body on the basis of a pre-specified second number of the total durations calculated by the duration calculation component and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals.

[0011] A seventh aspect of the present invention is a program for causing a computer to function as: a detection component that detects rises and falls of respective pulses of a plurality of pulse signals generated by a generation component, which generates the plurality of pulse signals with different phases in accordance with rotation of a rotating body; a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified first number of durations representing detection intervals of rises or falls detected by the detection component prior to the current rise or fall detected by the detection component; and a speed calculation component that includes a speed detection section that detects a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals, and a speed calculation section that, after a pre-specified number of speeds have been detected by the speed detection section, calculates by estimation, on the basis of a pre-specified second number of the speeds relating to rotation of the rotating body that have been detected by the speed detection section, the speed relating to rotation of the rotating body that is to be detected subsequent to the speed relating to rotation of the rotating body currently detected by the speed detection section.

[0012] A eighth aspect of the present invention is a speed estimation device including: a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing; a generation component that generates a plurality of pulse signals with different phases in accordance with passing of each of the plurality of detected portions in association with rotation of the rotating body; a detection component that detects reversals of the pulse signals generated by the generation component; a calculation component that, each time a reversal is detected by the detection component, calculates a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and an estimation component that estimates a speed relating to rotation of the rotating body on the basis of the duration calculated by the calculation component and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases.

[0013] A ninth aspect of the present invention is the speed estimation device of the eighth aspect, wherein the estimation component estimates an angular speed of the rotating body, by calculating a ratio of the reference rotation angle to the

duration calculated by the calculation component.

[0014] A tenth aspect of the present invention is the speed estimation device of the eighth aspect, wherein the estimation component estimates a linear speed at a position separated by a pre-specified distance in a rotation radial direction from a center of the rotating body, by calculating a ratio of a movement distance corresponding to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body to the duration calculated by the calculation component.

[0015] A eleventh aspect of the present invention is a speed estimation device including: a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing; a generation component that generates a plurality of pulse signals with different phases in accordance with passing of each of the plurality of detected portions in association with rotation of the rotating body; a detection component that detects reversals of the pulse signals generated by the generation component; a calculation component that, each time a reversal is detected by the detection component, calculates a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and an estimation component that estimates a speed relating to rotation of the rotating body on the basis of a plurality of the duration calculated by the calculation component and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases.

[0016] A twelfth aspect of the present invention is the speed estimation device of the eleventh aspect, wherein the estimation component estimates the duration to be calculated by the calculation component a next time, on the basis of the plurality of durations, and estimates the speed relating to rotation of the rotating body on the basis of the estimated duration and the reference rotation angle.

[0017] A thirteenth aspect of the present invention is the speed estimation device of the twelfth aspect, wherein the estimation component estimates the duration to be calculated by the calculation component the next time, on the basis of the plurality of durations, and estimates an angular speed of the rotating body, by calculating a ratio of the reference rotation angle to the estimated duration.

[0018] A fourteenth aspect of the present invention is the speed estimation device of the twelfth aspect, wherein the estimation component estimates the duration to be calculated by the calculation component the next time, on the basis of the plurality of durations, and estimates a linear speed at a position separated by a pre-specified distance in a rotation radial direction from a center of the rotating body, by calculating a ratio of a movement distance corresponding to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body to the estimated duration.

[0019] A fifteenth aspect of the present invention is the speed estimation device of the eleventh aspect, wherein the plurality of durations is two durations, being the duration calculated by the calculation component at a current time and the duration calculated by the calculation component at a previous time.

[0020] A sixteenth aspect of the present invention is a speed estimation device including: a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing; a generation component that generates a plurality of pulse signals with different phases in accordance with passing of each of the plurality of detected portions in association with rotation of the rotating body; a detection component that detects reversals of the pulse signals generated by the generation component; a calculation component that, each time a reversal is detected by the detection component, calculates a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and an estimation component provided with a first speed estimation section that estimates a speed relating to rotation of the rotating body on the basis of the duration calculated by the calculation component and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases, and a second speed estimation section that, after a plurality of the speed have been estimated by the first speed estimation section, estimates the speed relating to rotation of the rotating body subsequent to the speed estimated by the first speed estimation section at the current time, on the basis of the plurality of estimated speeds.

[0021] A seventeenth aspect of the present invention is the speed estimation device of the sixteenth aspect, wherein the first speed estimation section estimates an angular speed of the rotating body, by calculating a ratio of the reference rotation angle to the duration calculated by the calculation component, and the second speed estimation section, after a plurality of the angular speed have been estimated by the first speed estimation section, estimates an angular speed relating to rotation of the rotating body subsequent to the angular speed estimated by the first speed estimation section at the current time, on the basis of the plurality of estimated angular speeds.

[0022] An eighteenth aspect of the present invention is the speed estimation device of the sixteenth aspect, wherein the first speed estimation section estimates a linear speed at a position separated by a pre-specified distance in a rotation radial direction from a center of the rotating body, by calculating a ratio of a movement distance corresponding to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body to the duration calculated by the calculation component, and the second speed estimation section, after a plurality of the linear speed have been estimated by the first speed estimation section, estimates a linear

speed at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body subsequent to the linear speed estimated by the first speed estimation section at the current time, on the basis of the plurality of estimated linear speeds.

[0023] A nineteenth aspect of the present invention is an image forming device including: a speed estimation device of any one of the eighth, eleventh and sixteenth aspects; a recording head including a plurality of image forming elements that form constitutional units, which respectively constitute an image, at a pre-specified surface synchronously with a clock signal; an image conveyance component that conveys an image by causing the rotating body to function as one of a transfer body that transfers an image formed at a peripheral face thereof by the image forming elements to a surface of a recording medium and a conveyance body that, in a state in which a recording medium is retained at a peripheral face thereof, conveys the recording medium such that a surface of the recording medium opposes the image forming elements; and a correction component that corrects a period of the clock signal on the basis of the speed estimated by the estimation component and a distance between adjacent the constitutional units.

[0024] A twentieth aspect of the present invention is an image forming device including: a speed estimation device of any one of the eighth, eleventh and sixteenth aspects; a recording head including a plurality of image forming elements that form constitutional units, which respectively constitute an image, at a pre-specified surface; an image conveyance component that conveys an image by causing the rotating body to function as one of a transfer body that transfers an image formed at a peripheral face thereof by the image forming elements to a surface of a recording medium and a conveyance body that, in a state in which a recording medium is retained at a peripheral face thereof, conveys the recording medium such that a surface of the recording medium opposes the image forming elements; and a control component that, on the basis of the speed estimated by the estimation component, controls the rotation of the rotating body such that the speed relating to rotation of the rotating body is at a pre-specified speed.

[0025] The twenty-first aspect of the present invention is a program of instructions executable by the computer to perform a function, the function including: in association with rotation of a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing, detecting reversals of pulse signals generated by a generation component that generates a plurality of the pulse signals with different phases in accordance with passing of each of the plurality of detected portions; each time a reversal is detected, calculating a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and estimating a speed relating to rotation of the rotating body on the basis of the calculated duration and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases.

[0026] A twenty-second aspect of the present invention is a program of instructions executable by the computer to perform a function, the function including: in association with rotation of a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing, detecting reversals of pulse signals generated by a generation component that generates a plurality of the pulse signals with different phases in accordance with passing of each of the plurality of detected portions; each time a reversal is detected, calculating a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and estimating a speed relating to rotation of the rotating body on the basis of a plurality of the calculated duration and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases.

[0027] A twenty-third aspect of the present invention is a program of instructions executable by the computer to perform a function, the function including: in association with rotation of a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing, detecting reversals of pulse signals generated by a generation component that generates a plurality of the pulse signals with different phases in accordance with passing of each of the plurality of detected portions; each time a reversal is detected, calculating a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; estimating a speed relating to rotation of the rotating body on the basis of the calculated duration and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases; and after a plurality of the speed have been estimated, estimating the speed relating to rotation of the rotating body subsequent to the speed estimated at the current time, on the basis of the plurality of estimated speeds.

[0028] According to the first and fifth aspects of the present invention, tracking of variations of the speed relating to rotation of the rotating body may be improved and speeds relating to rotation of the rotating body may be calculated with high accuracy.

[0029] According to the second, third, sixth and seventh aspects of the present invention, tracking of variations of the speed relating to rotation of the rotating body may be further improved.

[0030] According to the fourth aspect of the present invention, an image may be formed synchronously with a clock signal for which tracking of variations of the speed relating to rotation of the rotating body is improved.

[0031] According to the eighth, eleventh, sixteenth and nineteenth to twenty-third aspects of the inventions, an effect

is provided in that a speed relating to rotation of a rotating body is estimated more accurately than in a case which does not include a function that estimates the speed relating to rotation of the rotating body using a duration required for detection of a pre-specified number of reversals of a plurality of pulse signals with phase differences, which are generated prior to the estimation by a generation component in association with rotation of the rotating body.

[0032] According to the ninth aspect of the invention, an effect is provided in that the speed relating to rotation of the rotating body is estimated more accurately than in a case which does not include a function that calculates a ratio of a reference rotation angle to a duration calculated by a calculation component.

[0033] According to the tenth aspect of the invention, an effect is provided in that a linear speed at a position separated by a pre-specified distance in a rotation radial direction from the center of the rotating body is estimated more accurately than in a case which does not include a function that calculates a ratio of a movement distance corresponding to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body to the duration calculated by the calculation component.

[0034] According to the twelfth aspect of the invention, an effect is provided in that the speed relating to rotation of the rotating body is estimated more accurately than in a case which does not include a function that estimates a duration to be calculated by the calculation component a next time, on the basis of plural durations, and estimates the speed relating to rotation of the rotating body on the basis of the estimated duration and the reference rotation angle.

[0035] According to the thirteenth aspect of the invention, an effect is provided in that an angular speed of the rotating body is estimated more accurately than in a case which does not include a function that estimates the duration to be calculated by the calculation component the next time, on the basis of the plural durations, and calculates the ratio of the reference rotation angle to the estimated duration.

[0036] According to the fourteenth aspect of the invention, an effect is provided in that the linear speed at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body is estimated, compared to a case which does not include a function that estimates the duration to be calculated by the calculation component the next time, on the basis of the plural durations, and calculates the ratio of the movement distance corresponding to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body to the estimated duration.

[0037] According to the fifteenth aspect of the invention, an effect is provided in that the speed relating to rotation of the rotating body is estimated more accurately than in a case in which the plural durations to be used when estimating the speed relating to rotation of the rotating body are not two durations that are a duration calculated by the calculation component at a current time and a duration calculated by the calculation component at a previous time.

[0038] According to the seventeenth aspect of the invention, an effect is provided in that the angular speed of the rotating body is estimated more accurately than in a case which does not include a function that estimates the angular speed of the rotating body by calculating the ratio of the reference rotation angle to the duration calculated by the calculation component and, after the plural angular speeds have been estimated, estimates the angular speed subsequent to the currently estimated angular speed on the basis of the plural estimated angular speeds.

[0039] According to the eighteenth aspect of the invention, an effect is provided in that the linear speed at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body is calculated more accurately than in a case which does not include a function that estimates the linear speed at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body by calculating the ratio of the movement distance corresponding to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body to the duration calculated by the calculation component and, after plural linear speeds have been estimated, estimates the linear speed subsequent to the currently estimated linear speed on the basis of the plural estimated linear speeds.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

Fig. 1 is a diagram illustrating structure of an image forming device relating to a first and seventh exemplary embodiments of the present invention;

Fig. 2 is a diagram illustrating structure of an inkjet ejection aperture face side of an inkjet recording head relating to the first and seventh exemplary embodiments of the present invention;

Fig. 3 is a block diagram illustrating principal structures of an electronic system of the image forming device relating to the first and the seventh exemplary embodiments of the present invention;

Fig. 4 is schematic views illustrating an example of variations in conveyance speed associated with increasing rotation angle of an image forming drum of the image forming device relating to the first and seventh exemplary embodiments of the present invention and an example of a situation in which impact positions of ink droplets are

altered due to the variations;

Fig. 5 is a flowchart of image formation control processing that is executed by a CPU of the first exemplary embodiment of the present invention;

Fig. 6 is a flowchart of speed calculation processing that is executed by an FPGA of the first exemplary embodiment of the present invention;

Fig. 7A is an image forming device equipped only with a related technology;

Fig. 7B is an image forming device relating to the first exemplary embodiment of the present invention;

Fig. 8 is a diagram for explaining a reduction in measurement accuracy when a measurement period is shortened;

Fig. 9 is views of cases in which a single dot line is drawn in a main scanning direction;

Fig. 10 is a flowchart of speed calculation processing that is executed by an FPGA of a second exemplary embodiment of the present invention;

Fig. 11 is a graph for describing details of the speed calculation processing of the second exemplary embodiment;

Fig. 12 is a graph for describing states of following of variations in a peripheral face speed V in the second exemplary embodiment;

Fig. 13 is a flowchart of image formation control processing that is executed by a CPU of a third exemplary embodiment;

Fig. 14 is a flowchart of speed calculation processing that is executed by an FPGA of the third exemplary embodiment;

Fig. 15 is a flowchart of speed calculation processing that is executed by an FPGA of a fourth exemplary embodiment;

Fig. 16 is a flowchart of speed calculation processing that is executed by an FPGA of a fifth exemplary embodiment;

Fig. 17 is a flowchart of speed calculation processing that is executed by an FPGA of a sixth exemplary embodiment;

Fig. 18 is a diagram illustrating another structure, which is an example to which the present invention is applicable;

Fig. 19 is a diagram for describing a variant example of an encoder;

Fig. 20 is a structural diagram illustrating structure of a rotary encoder relating to a seventh exemplary embodiment;

Fig. 21 is a flowchart illustrating a flow of processing of an image formation control processing program relating to the seventh exemplary embodiment;

Fig. 22 is a flowchart illustrating a flow of processing of a speed estimation processing program relating to the seventh exemplary embodiment;

Fig. 23 is a flowchart illustrating a flow of processing of a speed estimation processing program relating to an eighth exemplary embodiment;

Fig. 24 is a flowchart illustrating a flow of processing of an image formation control processing program relating to a ninth exemplary embodiment;

Fig. 25 is a flowchart illustrating a flow of processing of a speed estimation processing program relating to the ninth exemplary embodiment;

Fig. 26 is a flowchart illustrating a flow of processing of a speed estimation processing program relating to a tenth exemplary embodiment;

Fig. 27 is a flowchart illustrating a flow of processing of a speed estimation processing program relating to an eleventh exemplary embodiment; and

Fig. 28 is a flowchart illustrating a flow of processing of a speed estimation processing program relating to a twelfth exemplary embodiment.

DETAILED DESCRIPTION

[0041] Herebelow, the best embodiments for implementing the present invention will be described in detail with reference to the drawings.

- First Exemplary Embodiment -

[0042] Firstly, a first exemplary embodiment will be described. For the present exemplary embodiment, a case is described in which the present invention is applied to an inkjet-system image forming device. Fig. 1 is a diagram illustrating structure of an image forming device 10 relating to the present exemplary embodiment.

[0043] As shown in Fig. 1, a paper supply conveyance section 12 is provided at the image forming device 10. The paper supply conveyance section 12 supplies and conveys recording paper W , which is a recording medium. At a downstream side of the paper supply conveyance section 12 in a conveyance direction of the recording paper W , a processing fluid application section 14, an image formation section 16, an ink drying section 18, an image fixing section 20 and an ejection conveyance section 24 are provided along the conveyance direction of the recording paper W . The processing fluid application section 14 applies a processing fluid to a recording face (front face) of the recording paper W . The image formation section 16 forms an image on the recording face of the recording paper W . The ink drying section 18 dries the image that has been formed at the recording face. The image fixing section 20 fixes the dried image

to the recording paper W. The ejection conveyance section 24 conveys the recording paper W to which the image has been fixed to an ejection section 22.

[0044] The paper supply conveyance section 12 is provided with an accommodation section 26 that accommodates the recording paper W. A motor 30 is provided at the accommodation section 26. A paper supply apparatus is also provided at the accommodation section 26. The recording paper W is fed out from the accommodation section 26 toward the processing fluid application section 14 by the paper supply apparatus.

[0045] The processing fluid application section 14 is provided with an intermediate conveyance drum 28A and a processing fluid application drum 36. The intermediate conveyance drum 28A is rotatably disposed between the accommodation section 26 and the processing fluid application drum 36. A belt 32 spans between a rotation axle of the intermediate conveyance drum 28A and a rotation axle of the motor 30. Accordingly, rotary driving force of the motor 30 is transmitted to the intermediate conveyance drum 28A via the belt 32, and the intermediate conveyance drum 28A rotates in the direction of circular arc arrow A.

[0046] A retention member 34 is provided at the intermediate conveyance drum 28A. The retention member 34 nips a distal end portion of the recording paper W and retains the recording paper W. The recording paper W that is fed out from the accommodation section 26 to the processing fluid application section 14 is retained at a peripheral face of the intermediate conveyance drum 28A by the retention member 34, and is conveyed to the processing fluid application drum 36 by rotation of the intermediate conveyance drum 28A.

[0047] Similarly to the intermediate conveyance drum 28A, retention members 34 are provided at intermediate conveyance drums 28B, 28C, 28D and 28E, the processing fluid application drum 36, an image forming drum 44, an ink drying drum 56, an image fixing drum 62 and an ejection conveyance drum 68, which are described below. The recording paper W is passed along from upstream side drums to downstream side drums by these retention members 34.

[0048] The processing fluid application drum 36 is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0049] The recording paper W that has been conveyed by the intermediate conveyance drum 28A is taken up onto the processing fluid application drum 36 by the retention member 34 of the processing fluid application drum 36, and is conveyed in a state of being retained at a peripheral face of the processing fluid application drum 36.

[0050] At an upper portion of the processing fluid application drum 36, a processing fluid application roller 38 is disposed in a state of touching against the peripheral face of the processing fluid application drum 36. Processing fluid is applied to the recording face of the recording paper W on the peripheral face of the processing fluid application drum 36 by the processing fluid application roller 38. This processing fluid will react with the ink and coagulate a colorant (pigment), and promote separation of the colorant from a solvent.

[0051] The recording paper W to which the processing fluid has been applied by the processing fluid application section 14 is conveyed to the image formation section 16 by rotation of the processing fluid application drum 36.

[0052] The image formation section 16 is provided with the intermediate conveyance drum 28B and the image forming drum 44. The intermediate conveyance drum 28B is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0053] The recording paper W that has been conveyed by the processing fluid application drum 36 is taken up onto the intermediate conveyance drum 28B by the retention member 34 of the intermediate conveyance drum 28B of the image formation section 16, and is conveyed in a state of being retained at a peripheral face of the intermediate conveyance drum 28B.

[0054] The image forming drum 44, which is a rotating body, is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0055] The recording paper W that has been conveyed by the intermediate conveyance drum 28B is taken up onto the image forming drum 44 by the retention member 34 of the image forming drum 44, and is conveyed in a state of being retained at a peripheral face of the image forming drum 44.

[0056] Above the image forming drum 44, a head unit 46 is disposed close to the peripheral face of the image forming drum 44. The head unit 46 is provided with four inkjet recording heads 48, corresponding to each of the four colors yellow (Y), magenta (M), cyan (C) and black (K). These inkjet recording heads 48 are arranged along the peripheral direction of the image forming drum 44, and form an image by ejecting ink droplets from nozzles 48a, which will be described later, synchronously with clock signals, which will be described later, such that the ink droplets are superposed with a film of the processing fluid that has been formed on the recording face of the recording paper W by the processing fluid application section 14.

[0057] The image forming drum 44 is provided with a rotary encoder 52. The rotary encoder 52 relating to the present exemplary embodiment, in accordance with rotation of the image forming drum 44, generates and outputs plural pulse signals with respectively different phases. One pulse of the pulse signals corresponds to a pre-specified rotation angle θ_0 (for example, 1.257 milliradians). In the present exemplary embodiment, the rotary encoder 52 generates two pulse signals, of phase A and phase B.

[0058] The recording paper W on which the image has been formed at the recording face by the image formation

section 16 is conveyed to the ink drying section 18 by rotation of the image forming drum 44.

[0059] The ink drying section 18 is provided with the intermediate conveyance drum 28C and the ink drying drum 56. The intermediate conveyance drum 28C is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0060] The recording paper W that has been conveyed by the image forming drum 44 is taken up onto the intermediate conveyance drum 28C by the retention member 34 of the intermediate conveyance drum 28C, and is conveyed in a state of being retained at a peripheral face of the intermediate conveyance drum 28C.

[0061] The ink drying drum 56 is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0062] The recording paper W that has been conveyed by the intermediate conveyance drum 28C is taken up onto the ink drying drum 56 by the retention member 34 of the ink drying drum 56, and is conveyed in a state of being retained at a peripheral face of the ink drying drum 56.

[0063] Above the ink drying drum 56, a hot air heater 58 is disposed close to the peripheral face of the ink drying drum 56. Excess solvent in the image that has been formed on the recording paper W is removed by hot air from the hot air heater 58. The recording paper W at which the image on the recording face has been dried by the ink drying section 18 is conveyed to the image fixing section 20 by rotation of the ink drying drum 56.

[0064] The image fixing section 20 is provided with the intermediate conveyance drum 28D and the image fixing drum 62. The intermediate conveyance drum 28D is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0065] The recording paper W that has been conveyed by the ink drying drum 56 is taken up onto the intermediate conveyance drum 28D by the retention member 34 of the intermediate conveyance drum 28D, and is conveyed in a state of being retained at a peripheral face of the intermediate conveyance drum 28D.

[0066] The image fixing drum 62 is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0067] The recording paper W that has been conveyed by the intermediate conveyance drum 28D is taken up onto the image fixing drum 62 by the retention member 34 of the image fixing drum 62, and is conveyed in a state of being retained at a peripheral face of the image fixing drum 62.

[0068] At an upper portion of the image fixing drum 62, a fixing roller 64, which has a heater thereinside, is disposed in a state of abutting against a peripheral face of the image fixing drum 62. The recording paper W retained at the peripheral face of the image fixing drum 62 is heated by the heater in a state in which the recording paper W is pressing against the fixing roller 64, and thus colorant in the image formed at the recording face of the recording paper W is fused to the recording paper W, and the image is fixed to the recording paper W. The recording paper W to which the image has been fixed by the image fixing section 20 is conveyed to the ejection conveyance section 24 by rotation of the image fixing drum 62.

[0069] The ejection conveyance section 24 is provided with the intermediate conveyance drum 28E and the ejection conveyance drum 68. The intermediate conveyance drum 28E is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0070] The recording paper W that has been conveyed by the image fixing drum 62 is taken up onto the intermediate conveyance drum 28E by the retention member 34 of the intermediate conveyance drum 28E, and is conveyed in a state of being retained at a peripheral face of the intermediate conveyance drum 28E.

[0071] The ejection conveyance drum 68 is linked with the intermediate conveyance drum 28A by gears, and receives rotary force and rotates.

[0072] The recording paper W that has been conveyed by the intermediate conveyance drum 28E is taken up onto the ejection conveyance drum 68 by the retention member 34 of the ejection conveyance drum 68, and is conveyed toward the ejection section 22 in a state of being retained at a peripheral face of the ejection conveyance drum 68.

[0073] Fig. 2 is a diagram illustrating structure of an inkjet ejection aperture face side of the inkjet recording head 48 relating to the present exemplary embodiment.

[0074] As shown in Fig. 2, a plurality of the nozzles 48a, which respectively eject ink droplets, are formed in a face 90 of the inkjet recording head 48 that opposes the peripheral face of the image forming drum 44. The inkjet recording head 48 has a structure in which the plural nozzles 48a are arranged in a two-dimensional pattern (a staggered matrix form in the present exemplary embodiment) without overlapping in the direction of conveyance of the recording paper W by the image forming drum 44 (i.e., a sub-scanning direction). Thus, an increase in density of an effective nozzle spacing (projected nozzle pitch) as projected so as to lie along a head length direction (a direction orthogonal to the direction of conveyance of the recording paper W by the image forming drum 44 (which is below referred to simply as the conveyance direction)) is achieved.

[0075] Here, in the inkjet recording head 48 relating to the present exemplary embodiment, the plural nozzles 48a are arranged in two rows with respect to the sub-scanning direction and the two rows are separated by L mm in the sub-scanning direction. Hereafter, the plural nozzles 48a in the row at the conveyance direction upstream side are referred

to as nozzle group A, and the plural nozzles 48a in the row at the conveyance direction downstream side are referred to as nozzle group B.

[0076] Fig. 3 is a block diagram illustrating principal structures of an electronic system of the image forming device 10 relating to the present exemplary embodiment.

[0077] The image forming device 10 is structured to include a CPU (central processing unit) 70, a ROM (read-only memory) 72, a RAM (random access memory) 74, an NVM (non-volatile memory) 76, a UI (user interface) panel 78, an FPGA (field-programmable gate array) 79 and a communication I/F (communication interface) 80. In the present exemplary embodiment, an apparatus including this computer and the rotary encoder 52 serves as a speed calculation device that features a function of calculating a speed relating to rotation of the image forming drum 44 serving as the rotating body.

[0078] The CPU 70 administers operations of the image forming device 10 as a whole. The CPU 70 reads a program from the ROM 72 and executes image formation control processing.

[0079] The ROM 72 serves as a memory component and memorizes beforehand: a program for executing the image formation control processing that controls operations of the image forming device 10, which is described in detail hereafter; the rotation angle θ_0 that is represented by one pulse of the pulse signals outputted from the rotary encoder 52; a distance between the peripheral face of the image forming drum 44 (peripheral face of the rotating body) and the axial center of the image forming drum 44 (referred to hereafter in the present exemplary embodiment as distance R_0); a distance between neighboring dots (herein, between centers of the dots; referred to hereafter in the first exemplary embodiment as distance X_0); and various parameters and the like. In the present exemplary embodiment, a radius of the image forming drum 44 is employed as the pre-specified distance R_0 but this is not limiting and another value may be employed.

[0080] The RAM 74 is used as a work area during execution of various programs and the like. The NVM 76 memorizes various kinds of information that need to be retained when a power switch of the device is turned off.

[0081] The UI panel 78 is structured by a touch panel display, in which a transparent touch panel is superposed on a display, or the like. The UI panel 78 displays various kinds of information at a display screen of the display, and inputs required information, instructions and the like in accordance with a user touching the touch panel.

[0082] The FPGA 79 reads a program from the ROM 72 and executes the speed calculation processing.

[0083] The communication interface 80 is connected with a terminal device 82, such as a personal computer or the like, and receives image information representing an image to be formed at the recording paper W and various other kinds of information from the terminal device 82.

[0084] The CPU 70, the ROM 72, the RAM 74, the NVM 76, the UI panel 78, the FPGA 79 and the communication interface 80 are connected to one another via a system bus. Therefore, the CPU 70 may implement each of access to the ROM 72, the RAM 74 and the NVM 76, display of various kinds of information at the UI panel 78, acquisition of details of control instructions from users from the UI panel 78, reception of various kinds of information from the terminal device 82 via the communication interface 80, and control of the FPGA 79.

[0085] The image forming device 10 is further provided with a recording head controller 84 and a motor controller 86.

[0086] The recording head controller 84 controls operations of the inkjet recording head 48 in accordance with instructions from the CPU 70. The motor controller 86 controls operations of the motor 30.

[0087] The recording head controller 84 and the motor controller 86 are also connected to the above-mentioned system bus. Thus, the CPU 70 may implement control of operations of the recording head controller 84 and the motor controller 86.

[0088] The aforementioned rotary encoder 52 is also connected to the aforementioned system bus. Thus, the CPU 70 may receive the plural pulse signals generated by the rotary encoder 52.

[0089] Next, operation of the image forming device 10 relating to the present exemplary embodiment will be described.

[0090] In the image forming device 10 relating to the present exemplary embodiment, recording paper W is fed out from the accommodation section 26 to the intermediate conveyance drum 28A by the paper supply apparatus, the recording paper W is conveyed via the intermediate conveyance drum 28A, the processing fluid application drum 36 and the intermediate conveyance drum 28B to the image forming drum 44, and is retained at the peripheral face of the image forming drum 44. Then, ink droplets are ejected at the recording paper W on the image forming drum 44 from the nozzles 48a of the inkjet recording head 48 in accordance with image information. Thus, an image represented by the image information is formed on the recording paper W.

[0091] Now, a conveyance speed of the recording paper W that is retained at the peripheral face of the image forming drum 44 varies as is shown by the example in the graph of Fig. 4, for reasons such as variations in meshing and loading of the driving system gears and variations in speed of the motor itself. The vertical axis of the graph in Fig. 4 shows the conveyance speed of the recording paper W at the image forming drum 44, and the horizontal axis shows the rotation angle of the image forming drum 44 from the pre-specified reference position. The broken line circles in the image in Fig. 4 illustrate an example of impact positions of ink droplets ejected from the nozzles 48a in a case in which the conveyance speed of the recording paper W is constant at a speed V. The solid line circles in the image in Fig. 4 illustrate an example of impact positions of the ink droplets ejected from the nozzles 48a in a case in which there are variations in speed of the recording paper W.

[0092] In conditions in which the conveyance speed of the recording paper W at the image forming drum 44 varies in

this manner, clock signals of constant frequency are outputted to the inkjet recording heads 48, and when the ink droplets are ejected from the nozzles 48a at the inkjet recording heads 48 synchronously with these clock signals, an image that is formed by the ink droplets is deformed as shown in the example in Fig. 4.

[0093] Now, in order to suppress deformation of images due to speed variations, detecting or calculating the conveyance speed of the recording paper W and altering the frequency of the clock signals in accordance with the conveyance speed may be considered. In order to detect or calculate the conveyance speed of the recording paper W accurately, it is necessary to improve tracking of variations of the rotation speed of the image forming drum 44. Employing an encoder that generates pulse signals with high frequency for the rotary encoder 52 may be considered for improving tracking of variations in the rotation speed of the image forming drum 44. This is because it is thought that, when the rotary encoder 52 that generates pulse signals with high frequency is employed, a detection interval of the rotation speed of the image forming drum 44 is shorter and tracking of variations of the rotation speed of the image forming drum 44 improves. However, when the frequency is higher, a period of the pulse signals that are outputted from the rotary encoder 52 is shorter and measurement accuracy falls.

[0094] Accordingly, in the image forming device 10 relating to the present exemplary embodiment, in order to suppress deformation of an image due to variations in speed, the speed calculation processing is executed in order to improve tracking of variations in a speed relating to rotation of the image forming drum 44 and to calculate the speed relating to rotation of the image forming drum 44 with high accuracy.

[0095] Next, referring to Fig. 5, the image formation control processing that is executed by the CPU 70 of the image forming device 10 will be described. In the present exemplary embodiment, the image formation control processing is executed when an instruction for execution of the image formation processing, for forming an image at the recording paper W, and image information of an image formation subject are inputted from the terminal device 82 via the communication I/F 80 and the CPU 70 determines that this execution instruction and image information have been inputted.

[0096] Firstly, in step 100, an instruction to commence execution of the speed calculation processing is outputted to the FPGA 79, and the FPGA 79 performs control so as to commence execution of the speed calculation processing.

[0097] Now the speed calculation processing that is executed by the FPGA 79 will be described referring to Fig. 6.

[0098] Firstly, in step 200, the rotation angle θ_0 and the distance R_0 are read out from the ROM 72.

[0099] Then, in step 202, the motor controller 86 is controlled such that the image forming drum 44 commences rotary driving. Hence, the image forming drum 44 commences rotary driving due to the motor controller 86 controlling the motor 30 so as to commence the rotary driving.

[0100] Next, in step 204, the processing waits until the image forming drum 44 reaches a predetermined rotation speed (for example, 500 mm/s). Here, the judgement of whether or not the image forming drum 44 has reached the predetermined rotation speed is determined on the basis of pulse signals from the rotary encoder 52. When it is judged in step 204 that the image forming drum 44 has reached the predetermined rotation speed, the processing advances to the next step 206.

[0101] Then, in step 206, variables—a variable i, a variable T0, a variable T1, a variable T2, a variable T3 and a variable E1—are initialized by setting values of the variables to zero.

[0102] Next, in step 208, a timer is started for measuring a duration from a previous detection in the processing of step 210, details of which are described below, until a next detection. Accordingly, the duration is measured in unit time intervals (for example, of 10 ns (nanoseconds)), and the duration that is measured each time the measured duration is updated is put into the variable i. More specifically, the duration is computed from a clock count of a counter installed at the FPGA 79.

[0103] Then, in step 210, rises and falls of the respective pulses of the two pulse signals of phase A and phase B outputted from the rotary encoder 52 are detected for. Accordingly, when a pulse of either of the two pulse signals with phase A and phase B rises, the rise of the pulse of that signal is detected, and when a pulse of either of the two pulse signals with phase A and phase B falls, the fall of the pulse of that signal is detected.

[0104] Next, in step 212, it is judged whether or not a rise of a pulse has been detected or a fall of a pulse has been detected in step 210. If it is judged in step 212 that a pulse rise has been detected or a pulse fall has been detected in step 210, the processing advances to the next step 214. On the other hand, if it is judged in step 212 that no pulse rise has been detected and no pulse fall has been detected in step 210, the processing returns to step 210, and rises and falls of the respective pulses of the two pulse signals with phase A and phase B outputted from the rotary encoder 52 are again detected for.

[0105] In step 214, the value of variable T0 is updated by putting the value of variable T1 into variable T0, the value of variable T1 is updated by putting the value of variable T2 into variable T1, the value of variable T2 is updated by putting the value of variable T3 into variable T2, and the value of variable T3 is updated by putting the value of variable i into variable T3. Then the value of variable E1 is updated by putting the sum of the value of variable T0, the value of variable T1, the value of variable T2 and the value of variable T3 ($T0+T1+T2+T3$) into variable E1. Then, initialization is performed by stopping the timer that started in step 208 and setting the value of variable i to zero. Here, if the detection of a pulse rise or detection of a pulse fall in the most recent processing of step 210 is a first (initial) detection, the value of variable i that has been put into variable T3 in the present step 214 is the duration from the present speed calculation

processing starting until a first detection. If the detection of a pulse rise or detection of a pulse fall in the most recent processing of step 210 is a second or subsequent detection, this value of variable i is the duration from the previous detection by the processing of step 210 to the current detection by the processing of step 210. That is, in step 214, each time a rise or fall is detected in step 210, the duration $E1$ is calculated, which is a total of durations ($T0$, $T1$, $T2$ and $T3$) representing detection intervals of the rises and falls that have been detected in a pre-specified number ($T0$ to $T3$ being four thereof) prior to the current rise or fall detected in step 210.

[0106] Then, in step 216, by determining whether or not all the values of variable $T0$, variable $T1$, variable $T2$ and variable $T3$ are greater than zero, it is determined whether or not information that will be required when calculating a speed in step 218, details of which are described below, is all present.

[0107] In step 216, if it is judged that there is a variable among all the variables of variable $T0$, variable $T1$, variable $T2$ and variable $T3$ whose value is zero, it is determined that all the information that would be required when calculating the speed in step 218 whose details are described below is not present, and the processing returns to step 208. On the other hand, if it is judged that the values of all the variables of variable $T0$, variable $T1$, variable $T2$ and variable $T3$ are greater than zero, it is determined that all the information that will be required when calculating the speed in step 218 whose details are described below is present, and the processing advances to the next step 218.

[0108] In step 218, a speed relating to rotation of the image forming drum 44 is calculated on the basis of the total duration $E1$ computed in step 214 and the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signals. More specifically, in step 218, a peripheral face speed V of the image forming drum 44 is calculated by dividing a movement distance ($R_0\theta_0$) of the peripheral face of the image forming drum 44 through the rotation angle θ_0 by the total duration $E1$, as in the following equation (1).

$$V = (R_0\theta_0)/E1 \quad \text{Equation (1)}$$

[0109] Then, in step 220, the value of the peripheral face speed V calculated in step 218 is outputted (reported) to the CPU 70.

[0110] Next, in step 222, it is judged whether or not an instruction to stop execution of the speed calculation processing has been received from the CPU 70. If it is judged in step 222 that an instruction to stop execution of the speed calculation processing has not been received, the processing returns to step 208. On the other hand, if it is judged in step 222 that an instruction to stop execution of the speed calculation processing has been received, the present speed calculation processing ends.

[0111] Now the description of the image formation control processing shown in Fig. 5 is resumed. In the next step 102, it is determined whether or not a value of the peripheral face speed V has been received from the FPGA 79. The determination processing of step 102 is repeated until reception is determined. When reception is determined in step 102, the processing advances to the next step 104.

[0112] Then, in step 104, the distance X_0 is read from the ROM 72, and the peripheral face speed calculated by the speed calculation processing is used to calculate, with the following equation (2), a period P of the clock signal that prescribes timings of ejections of ink droplets from the nozzles 48a.

$$P = X_0/V$$

$$= X_0E1/(R_0\theta_0) \quad \text{Equation (2)}$$

[0113] Then, in step 106, a clock signal with the calculated period P is generated and instructions to eject ink droplets from the nozzles 48a, synchronously with this clock signal, are outputted to the recording head controller 84 in accordance with the received image information. Hence, the recording head controller 84 controls the nozzles 48a so as to eject droplets in accordance with the received image information synchronously with this clock signal. Thus, an image represented by the image information is formed at the recording face of the recording paper W without being affected by changes in the conveyance speed of the recording paper W .

[0114] Next, in step 108, it is judged whether or not image formation with the received image information has ended. If this judgement is negative, the processing returns to step 102. On the other hand, if the judgement in step 108 is positive, the processing advances to the next step 110. In step 110, an instruction to stop execution of the speed calculation processing is outputted to the FPGA 79. Then, the image formation control processing ends.

[0115] The speed calculation device of the image forming device 10 of the present exemplary embodiment as described above is constituted to include the rotary encoder 52 to serve as a generation component that generates plural pulse signals with different phases (in the present exemplary embodiment, the pulse signals with phase A and phase B) in accordance with rotation of the image forming drum 44 which serves as the rotating body that rotates. The speed calculation device of the image forming device 10 of the present exemplary embodiment detects rises and falls of respective pulses of the plural pulse signals generated by the rotary encoder 52 in step 210. Then the speed calculation device of the image forming device 10 of the present exemplary embodiment, each time a rise or fall is detected in step 210, calculates, in step 214, the total duration E1 of durations (T0, T1, T2 and T3) representing detection intervals of the rises and falls detected in the pre-specified number (T0, T1, T2 and T3 being four) prior to the current rise or fall detected in step 210. Hence, the speed calculation device of the image forming device 10 of the present exemplary embodiment calculates a speed relating to rotation of the image forming drum 44 in step 218 on the basis of the total duration E1 and the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signals generated by the rotary encoder 52. More specifically, the peripheral face speed V of the image forming drum 44 is calculated in step 218 by dividing the movement distance ($R_0\theta_0$) of the peripheral face of the image forming drum 44, through the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signals, by the total duration E1. Further, the image forming device 10 of the present exemplary embodiment is constituted to include inkjet recording heads 48 in which the nozzles 48a that serve as plural image forming elements, which form dots that respectively constitute an image at a predetermined surface synchronously with a clock signal, are arranged. The image forming drum 44 rotates with the peripheral face thereof opposing the plural nozzles 48a in the state in which the recording paper W, which serves as the recording medium, is retained at the peripheral face of the image forming drum 44, such that the image is formed at the recording paper W by the respective plural nozzles 48a. The image forming device 10 of the present exemplary embodiment calculates a period P of the clock signal in step 104 on the basis of the peripheral face speed V calculated by the speed calculation device and the distance X_0 between neighboring dots. Accordingly, if, for example, tracking of variations of the peripheral face speed V of an image forming drum as represented by a speed 62, which is detected on the basis of pulse signals from a rotary encoder by an image forming device that is provided only with a related technology, for an actual speed V shown in Fig. 7A (61) is compared with tracking of variations of the peripheral face speed V of the image forming drum 44 as represented by a speed 64, which is detected on the basis of plural pulse signals from the rotary encoder 52 by the speed calculation device of the image forming device 10 of the present exemplary embodiment, for an actual speed V shown in Fig. 7B (63), it is understood that the image forming device 10 of the present exemplary embodiment is more excellent after a time t_0 .

[0116] In the above description, an example is described of calculating the peripheral face speed using the total duration E1 of the pre-specified number (T0, T1, T2 and T3 being four) of durations (T0, T1, T2 and T3) representing detection intervals of rises and falls that are detected. A method that gets closer to variations of the actual peripheral face speed of the image forming drum 44 by calculating the peripheral face speed using the durations that represent detection intervals (T0, T1, T2 and T3) may be considered. However, with such a method, accuracy of the calculated peripheral face speed falls for the reason described below. This reason will be described using Fig. 8. Fig. 8 shows pulses of the pulse signals with phase A and phase B that are outputted from the rotary encoder and thresholds (limits) of FPGA edge detection (detection of a rise or fall). The output pulses of the rotary encoder are slightly sloped. If, for example, the threshold is lower than a midpoint of the pulse voltages as shown in Fig. 8, then rise-to-fall intervals will be shorter than fall-to-rise intervals. In addition, phases of phase A and phase B depend on positional accuracy of detectors (which here are detectors of the rotary encoder). Therefore, if one pulse is divided into four, the phase differences will not be precisely 90° . That is, a single pulse will not be strictly equally divided. Therefore, if the period P of a clock signal is calculated with the above-mentioned method and the clock signal with the calculated period P is used during image formation, accuracy will fall. For this reason, it is preferable to use the total duration E1 to calculate the peripheral face speed V.

[0117] With the image forming device equipped with the related technology and the image forming device 10 of the present exemplary embodiment, as shown in Fig. 9, a single dot line (single line) was drawn in the main scanning direction and an offset of the dots δ was measured. Measurement results are shown below in table 1.

Table 1

	Dot offset δ
Phase A rise (conventional)	3.3 μm
Detecting rises and falls of phases A and B	2.2 μm

[0118] As shown in table 1, with the image forming device equipped with the related technology, the dot offset δ was 3.3 μm and with the image forming device 10 of the present exemplary embodiment, the dot offset δ was 2.2 μm .

[0119] Conditions here are as shown below.

Conditions

5 **[0120]**

Rotation speed V_0 : 200 mm/s
 Printing drum (image forming drum) radius R: 100 mm
 Speed variation ΔV : 1%
 10 Speed variation frequency: 5 Hz
 2-dimensional head nozzle spacing L: 4 mm
 Rotary encoder: 500 pulses/revolution
 FPGA clock frequency: 20 MHz

15 - Second Exemplary Embodiment -

[0121] Next, a second exemplary embodiment will be described. Portions of the present exemplary embodiment that are the same as in the first exemplary embodiment are assigned the same reference numerals and will not be described.

20 **[0122]** In the first exemplary embodiment, an example is described in which the program for executing the speed calculation processing shown in Fig. 6 is memorized in the ROM 72, and the FPGA 79 reads the program from the ROM 72 and executes the speed calculation processing shown in Fig. 6. In the present exemplary embodiment, a program for executing speed calculation processing shown in Fig. 10 is memorized in the ROM 72 in advance, and the FPGA 79 reads this program from the ROM 72 and executes the speed calculation processing shown in Fig. 10.

25 **[0123]** Now the speed calculation processing that is executed by the FPGA 79 of the present exemplary embodiment will be described referring to Fig. 10.

[0124] Steps 200, 202 and 204 (steps 200 to 204) are the same as in the first exemplary embodiment, so will not be described. In the present exemplary embodiment, after step 204 the processing advances to step 207. In step 207, variables-a variable i, a variable T0, a variable T1, a variable T2, a variable T3, a variable T4, a variable E1 and a variable E2-are initialized by setting the values of the variables to zero.

30 **[0125]** Next, in step 208, the same as in the first exemplary embodiment, a timer is started for measuring a duration from a previous detection in the processing of step 210, details of which are described below, until a next detection.

[0126] Then, in step 210, the same as in the first exemplary embodiment, rises and falls of the respective pulses of the two pulse signals of phase A and phase B outputted from the rotary encoder 52 are detected for.

35 **[0127]** Next, in step 212, the same as in the first exemplary embodiment, it is judged whether or not a rise of a pulse has been detected or a fall of a pulse has been detected in step 210. If it is judged in step 212 that a pulse rise has been detected or a pulse fall has been detected in step 210, the processing advances to the next step 215. On the other hand, if it is judged in step 212 that no pulse rise has been detected and no pulse fall has been detected in step 210, the processing returns to step 210, and rises and falls of the respective pulses of the two pulse signals with phase A and phase B outputted from the rotary encoder 52 are again detected for.

40 **[0128]** In step 215, the value of variable T0 is updated by putting the value of variable T1 into variable T0, the value of variable T1 is updated by putting the value of variable T2 into variable T1, the value of variable T2 is updated by putting the value of variable T3 into variable T2, the value of variable T3 is updated by putting the value of variable T4 into variable T3, and the value of variable T4 is updated by putting the value of variable i into variable T4. Then the value of variable E1 is updated by putting the sum of the value of variable T0, the value of variable T1, the value of variable T2 and the value of variable T3 ($T0+T1+T2+T3$) into variable E1, and the value of variable E2 is updated by putting the sum of the value of variable T1, the value of variable T2, the value of variable T3 and the value of variable T4 ($T1+T2+T3+T4$) into variable E2. Then, initialization is performed by stopping the timer that started in step 208 and setting the value of variable i to zero. Here, if the detection of a pulse rise or detection of a pulse fall in the most recent processing of step 210 is a first (initial) detection, the value of variable i that has been put into variable T4 in the present
 45 step 215 is the duration from the present speed calculation processing starting until a first detection. If the detection of a pulse rise or detection of a pulse fall in the most recent processing of step 210 is a second or subsequent detection, this value of variable i is the duration from the previous detection by the processing of step 210 to the current detection by the processing of step 210. That is, in step 215, each time a rise or fall is detected in step 210, the duration E1 is calculated, which is a total of durations (T0, T1, T2 and T3) representing detection intervals of the rises and falls that have been detected in a pre-specified number (T0 to T3 being four thereof) prior to the current rise or fall detected in step 210, in addition to which the duration E2 is calculated, which is a total of durations (T1, T2, T3 and T4) representing detection intervals of the rises and falls which have been detected in a pre-specified first number (T1 to T4 being four thereof) prior to the current rise or fall detected in step 210.
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[0129] Then, in step 217, by determining whether or not all the values of variable T0, variable T1, variable T2, variable T3 and variable T4 are greater than zero, it is determined whether or not information that will be required when calculating a speed in step 221, details of which are described below, is all present.

[0130] In step 217, if it is judged that there is a variable among all the variables of variable T0, variable T1, variable T2, variable T3 and variable T4 whose value is zero, it is determined that all the information that would be required when calculating the speed in step 221 whose details are described below is not present, and the processing returns to step 208. On the other hand, if it is judged that the values of all the variables of variable T0, variable T1, variable T2, variable T3 and variable T4 are greater than zero, it is determined that all the information that will be required when calculating the speed in step 221 whose details are described below is present, and the processing advances to the next step 219.

[0131] In step 219, for each of the total durations E1 and E2 that have been calculated in step 215, control is performed so as to memorize the total durations E1 and E2 in the NVM 76, which serves as a memory component, in a pre-specified number (E1 and E2 being two in the present exemplary embodiment; this number is referred to as a third number) to serve as a history. Accordingly, the total durations E1 and E2 are memorized in the NVM 76.

[0132] Then, in step 221, a speed relating to rotation of the image forming drum 44 is calculated on the basis of, of the third number of total durations E1 and E2 memorized in the NVM 76, a second number of total durations E1 and E2 (E1 and E2 being two in the present exemplary embodiment) and the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signal. More specifically, in step 221 a duration E, for calculating the speed relating to rotation of the image forming drum 44 (the peripheral face speed V in the present exemplary embodiment) that is to be calculated a next time, is estimated by linear extrapolation based on, of the third number of total durations E1 and E2 memorized in the NVM 76, the second number of total durations E1 and E2 (E1 and E2 being two in the present exemplary embodiment), and the peripheral face speed V of the image forming drum 44 is calculated by dividing the movement distance ($R_0\theta_0$) of the peripheral face of the image forming drum 44 through the rotation angle θ_0 by the estimated duration E, as in the following equation (3).

$$V = (R_0\theta_0)/E \quad \text{Equation (3)}$$

[0133] Then the processing advances to step 220 and subsequent processing the same as in the first exemplary embodiment is performed.

[0134] Now, the processing of step 221 will be more specifically described with reference to Fig. 11.

[0135] As shown in Fig. 11, a period (total duration) represented by the most recent pulse signals from the rotary encoder 52 is E2, and a period (total duration) one step prior thereto is E1. A speed V1 ($= (R_0\theta_0)/E1$) calculated with E1 is an average speed over t_1 - t_5 , and a speed V2 ($= (R_0\theta_0)/E2$) calculated with E2 is an average speed over t_2 - t_6 . The speed V1 and the speed V2 correspond to speeds at times t_3 and t_4 , respectively.

[0136] The speed to be estimated from E1 and E2 here is the speed V in the interval t_6 - t_7 . Assuming that intervals t_i - t_{i+1} are substantially equal intervals, the speed V at an intermediate point during t_6 - t_7 is represented by the following equation (4) according to linear extrapolation.

$$\begin{aligned} V &= (R_0\theta_0)/(3.5*E2-2.5*E1) \\ &= 2(R_0\theta_0)/(7*E2-5*E1) \end{aligned} \quad \text{Equation (4)}$$

[0137] Herein, "*" is a symbol representing multiplication. That is, "A*B" represents the product of A and B.

[0138] States of tracking of variations of the peripheral face speed V in such a case are as shown in Fig. 12.

[0139] Then the processing advances to step 220 and subsequent processing the same as in the first exemplary embodiment is performed.

[0140] Here, the period P of the clock signal that is calculated in step 102 of the present exemplary embodiment is as in the following equation (5).

$$P = X_0/V$$

$$= X_0(3.5 \cdot E_2 - 2.5 \cdot E_1) / (R_0 \theta_0)$$

$$= X_0(7 \cdot E_2 - 5 \cdot E_1) / 2(R_0 \theta_0)$$

Equation (5)

[0141] In the above description, a speed at an intermediate point during t_6 - t_7 is estimated. However, a speed at t_6 may be estimated to serve as a representative speed V . In step 221 in this case, the total duration E calculated for the next time thereafter is estimated by linear extrapolation based on, of the pre-specified third number of total durations E_1 and E_2 memorized in the NVM 76, the second number of total durations E_1 and E_2 (E_1 and E_2 being two in the present exemplary embodiment), and the peripheral face speed V of the image forming drum 44 is calculated by dividing the movement distance ($R_0 \theta_0$) of the peripheral face of the image forming drum 44 through the rotation angle θ_0 by this estimated total duration E . The period P of the clock signal that is calculated in step 102 in this case is represented by the following equation (6).

$$P = X_0/V$$

$$= X_0(3 \cdot E_2 - 2 \cdot E_1) / (R_0 \theta_0)$$

Equation (6)

[0142] Similarly, a speed at t_7 may be estimated to serve as a representative speed V . In step 221 in this case, the total duration E calculated for the next time thereafter is estimated by linear extrapolation based on, of the pre-specified third number of total durations E_1 and E_2 memorized in the NVM 76, the second number of total durations E_1 and E_2 (two of E_1 and E_2 in the present exemplary embodiment), and the peripheral face speed V of the image forming drum 44 is calculated by dividing the movement distance ($R_0 \theta_0$) of the peripheral face of the image forming drum 44 through the rotation angle θ_0 by this estimated total duration E . The period P of the clock signal that is calculated in step 102 in this case is represented by the following equation (7).

$$P = X_0/V$$

$$= X_0(4 \cdot E_2 - 3 \cdot E_1) / (R_0 \theta_0)$$

Equation (7)

[0143] With the image forming device equipped with the related technology and the image forming device 10 of the present exemplary embodiment, a single dot line (single line) was drawn in the main scanning direction, as shown in Fig. 9, and an offset of the dots δ was measured. Measurement results are shown below in table 2.

Table 2

	Dot offset δ
Phase A rise (conventional)	3.3 μm
Detecting rises and falls of phases A and B + extrapolation	1.5 μm

[0144] As shown in table 2, with the image forming device equipped with the related technology, the dot offset δ was 3.3 μm , and with the image forming device 10 of the present exemplary embodiment, the dot offset δ was 1.5 μm .

[0145] Conditions in this case are the same as those described for table 1.

[0146] The speed calculation device of the image forming device 10 of the present exemplary embodiment as described above, each time a rise or fall is detected in step 210, calculates, in step 215, the totals E_1 and E_2 of durations (T_0 to

T3 and T1 to T4) representing detection intervals of rises and falls detected in the pre-specified first number (T0, T1, T2 and T3 being four and T1, T2, T3 and T4 being four) prior to the current rise or fall detected in step 210. For each of the calculated total durations E1 and E2, control is performed in step 219 to memorize a pre-specified number (two in the present exemplary embodiment) of total durations E1 and E2 in the NVM 76 as a history. The duration E is estimated on the basis of, of the pre-specified number of total durations E1 and E2 memorized in the NVM 76, the second number (two in the present exemplary embodiment) of total durations E1 and E2, and the peripheral face speed V of the image forming drum 44 is calculated in step 221 by dividing the movement distance ($R_0\theta_0$) of the peripheral face of the image forming drum 44 through the rotation angle θ_0 by the estimated duration E.

[0147] Here, the pre-specified third number and second number may be numbers larger than two, and the duration E may be estimated by higher order extrapolation in step 221 on the basis of the second number of total durations. Furthermore, the pre-specified third number and second number need not be the same number. It is sufficient that the pre-specified third number be at least as large as the second number.

- Third Exemplary Embodiment -

[0148] Next, a third exemplary embodiment will be described. Portions of the present exemplary embodiment that are the same as in the first exemplary embodiment are assigned the same reference numerals and will not be described.

[0149] In the first exemplary embodiment, an example is described in which the programs for executing the image formation control processing shown in Fig. 5 and the speed calculation processing shown in Fig. 6 are memorized in the ROM 72, the CPU 70 reads the program from the ROM 72 and executes the image formation control processing shown in Fig. 5, and the FPGA 79 reads the program from the ROM 72 and executes the speed calculation processing shown in Fig. 6. In the present exemplary embodiment, programs for executing the image formation control processing shown in Fig. 13 and the speed calculation processing shown in Fig. 14 are memorized in the ROM 72 in advance, the CPU 70 reads the program from the ROM 72 and executes the image formation control processing shown in Fig. 13, and the FPGA 79 reads the program from the ROM 72 and executes the speed calculation processing shown in Fig. 14.

[0150] Now the image formation control processing that is executed by the CPU 70 of the present exemplary embodiment will be described referring to Fig. 13.

[0151] Firstly, the same as in the first exemplary embodiment, in step 100, an instruction to commence execution of the speed calculation processing is outputted to the FPGA 79, and the FPGA 79 performs control so as to commence execution of the speed calculation processing.

[0152] Now the speed calculation processing that is executed by the FPGA 79 of the present exemplary embodiment will be described referring to Fig. 14.

[0153] Firstly, in step 201, the rotation angle θ_0 is read from the ROM 72. Then the processing advances to step 202.

[0154] Steps 202, 204, 206, 208, 210, 212, 214 and 216 (steps 202 to 216) are the same as in the first exemplary embodiment, so will not be described. In step 216 in the present exemplary embodiment, by judging whether or not all the values of variable T0, variable T1, variable T2 and variable T3 are greater than zero, it is determined (when the judgement is positive) when information that will be required when calculating a speed in step 230, details of which are described below, is all present, after which the processing advances to step 230.

[0155] In step 230, a speed relating to rotation of the image forming drum 44 is calculated on the basis of the duration E1 calculated in the earlier-described step 214 and the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signal. More specifically, in step 230, an angular speed W of the image forming drum 44 is calculated by dividing the rotation angle θ_0 by the duration E1, as in the following equation (8).

$$W = \theta_0/E1$$

Equation (8)

[0156] Then, in step 232, the value of the angular speed W calculated in step 230 is outputted (reported) to the CPU 70. Then the processing advances to step 222.

[0157] Now the description of the image formation control processing shown in Fig. 13 is resumed. In the next step 103, it is determined whether or not a value of the angular speed W has been received from the FPGA 79. The determination processing of step 103 is repeated until reception is determined. When reception is determined in step 103, the processing advances to the next step 105.

[0158] Then, in step 105, the distance R_0 and the distance X_0 are read from the ROM 72, and the angular speed W calculated in the above speed calculation processing is used to calculate, with the following equation (9), a period P of the clock signal that prescribes timings of ejections of ink droplets from the nozzles 48a.

$$P = X_0/R_0W$$

$$= X_0E1/(R_0\theta_0)$$

Equation (9)

[0159] Then the processing advances to step 106, and subsequent processing the same as in the first exemplary embodiment is performed, except that the processing returns to step 103 when the determination of step 108 is negative in the present exemplary embodiment.

[0160] The speed calculation device of the image forming device 10 of the present exemplary embodiment as described above is constituted to include the rotary encoder 52 to serve as the generation component that generates plural pulse signals with different phases (in the present exemplary embodiment, the pulse signals with phase A and phase B) in accordance with rotation of the image forming drum 44 which serves as the rotating body that rotates. The speed calculation device of the image forming device 10 of the present exemplary embodiment detects rises and falls of respective pulses of the plural pulse signals generated by the rotary encoder 52 in step 210. Then the speed calculation device of the image forming device 10 of the present exemplary embodiment, each time a rise or fall is detected in step 210, calculates, in step 214, the total duration E1 of durations (T0, T1, T2 and T3) representing detection intervals of the rises and falls detected in the pre-specified number (T0, T1, T2 and T3 being four) prior to the current rise or fall detected in step 210. Hence, the speed calculation device of the image forming device 10 of the present exemplary embodiment calculates a speed relating to rotation of the image forming drum 44 in step 230 on the basis of the total duration E1 and the rotation angle θ_0 of the image forming drum 44 corresponding to one pulse of the pulse signal generated by the rotary encoder 52. More specifically, the angular speed W of the image forming drum 44 is calculated in step 230 by dividing the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signals by the total duration E1. Further, the image forming device 10 of the present exemplary embodiment is constituted to include inkjet recording heads 48 in which the nozzles 48a that serve as plural image forming elements, which form dots that respectively constitute an image at a predetermined surface synchronously with a clock signal, are arranged. The image forming drum 44 rotates with the peripheral face thereof opposing the plural nozzles 48a in the state in which the recording paper W, which serves as the recording medium, is retained at the peripheral face of the image forming drum 44, such that the image is formed at the recording paper W by the respective plural nozzles 48a. The image forming device 10 of the present exemplary embodiment calculates a period P of the clock signal in step 105 on the basis of the angular speed W calculated by the speed calculation device, the distance R_0 between the axis of the image forming drum 44 and the peripheral face of the image forming drum 44, and the distance X_0 between neighboring dots.

- Fourth Exemplary Embodiment -

[0161] Next, a fourth exemplary embodiment will be described. Portions of the present exemplary embodiment that are the same as in the first exemplary embodiment, the second exemplary embodiment and the third exemplary embodiment are assigned the same reference numerals and will not be described.

[0162] In the present exemplary embodiment, programs for executing the image formation control processing shown in Fig. 13 and the speed calculation processing shown in Fig. 15 are memorized in the ROM 72 in advance, the CPU 70 reads the program from the ROM 72 and executes the image formation control processing shown in Fig. 13, and the FPGA 79 reads the program from the ROM 72 and executes the speed calculation processing shown in Fig. 15.

[0163] Now the speed calculation processing that is executed by the FPGA 79 of the present exemplary embodiment will be described referring to Fig. 15.

[0164] Firstly, in step 201, the same as in the third exemplary embodiment, the rotation angle θ_0 is read from the ROM 72. Then the processing advances to step 202.

[0165] Steps 202, 204, 207, 208, 210, 212, 215, 217 and 219 (steps 202 to 219) are the same as in the second exemplary embodiment, so will not be described. In the present exemplary embodiment, after step 219 the processing advances to step 240.

[0166] In step 240, a speed relating to rotation of the image forming drum 44 is calculated on the basis of the pre-specified second number of total durations E 1 and E2 (E 1 and E2 being two in the present exemplary embodiment) and the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signal. More specifically, in step 240 a duration E, for calculating the speed relating to rotation of the image forming drum 44 (the angular speed W in the present exemplary embodiment) that is to be calculated a next time, is estimated by linear extrapolation similarly to the second exemplary embodiment, based on, of the total durations E1 and E2 memorized in the NVM 76, the pre-specified second number of total durations E1 and E2 (E1 and E2 being two in the present exemplary embodiment), and the angular speed W of the image forming drum 44 is calculated by dividing the rotation angle θ_0 by the estimated

duration E, as in the following equation (10).

$$W = \theta_0/E$$

$$= \theta_0/(3.5 * E2 - 2.5 * E1)$$

$$= 2\theta_0/(7 * E2 - 5 * E1)$$

Equation (10)

[0167] Then the processing advances to step 242. In step 242, the value of the angular speed W calculated in step 240 is outputted (reported) to the CPU 70. Then the processing advances to step 222 and subsequent processing the same as in the third exemplary embodiment is performed.

[0168] In the above description, a speed at an intermediate point during t_6 - t_7 is estimated. However, a speed at t_6 may be estimated to serve as the representative speed W. The angular speed W calculated in step 240 in this case is represented by the following equation (11).

$$W = \theta_0/(3 * E2 - 2 * E1)$$

Equation (11)

[0169] Similarly, a speed at t_7 may be estimated to serve as the representative speed W. The angular speed W that is calculated in step 240 in this case is represented by the following equation (12).

$$W = \theta_0/(4 * E2 - 3 * E1)$$

Equation (12)

[0170] The speed calculation device of the image forming device 10 of the present exemplary embodiment as described above, each time a rise or fall is detected in step 210, calculates, in step 215, the durations of the totals E1 and E2 of durations (T0 to T3 and T1 to T4) representing detection intervals of rises and falls detected in the pre-specified first number (T0, T1, T2 and T3 being four and T1, T2, T3 and T4 being four) prior to the current rise or fall detected in step 210. For each of the calculated total durations E1 and E2, control is performed in step 219 to memorize a pre-specified number (two in the present exemplary embodiment) of the total durations E1 and E2 in the NVM 76 as a history. The duration E is estimated on the basis of, of the pre-specified number of total durations E1 and E2 memorized in the NVM 76, the second number (two in the present exemplary embodiment) of total durations E1 and E2, and the angular speed W of the image forming drum 44 is calculated in step 240 by dividing the rotation angle θ_0 by the estimated duration E.

- Fifth Exemplary Embodiment -

[0171] Next, a fifth exemplary embodiment will be described. Portions of the present exemplary embodiment that are the same as in the first exemplary embodiment, the second exemplary embodiment, the third exemplary embodiment and the fourth exemplary embodiment are assigned the same reference numerals and will not be described.

[0172] In the present exemplary embodiment, programs for executing the image formation control processing shown in Fig. 5 and the speed calculation processing shown in Fig. 16 are memorized in the ROM 72 in advance, the CPU 70 reads the program from the ROM 72 and executes the image formation control processing shown in Fig. 5, and the FPGA 79 reads the program from the ROM 72 and executes the speed calculation processing shown in Fig. 16.

[0173] Now the speed calculation processing that is executed by the FPGA 79 of the present exemplary embodiment will be described referring to Fig. 16.

[0174] Steps 200, 202 and 204 (steps 200 to 204) are the same as in the first exemplary embodiment, so will not be described. In the present exemplary embodiment, after step 204 the processing advances to step 250.

[0175] In step 250, variables-a variable i, a variable T0, a variable T1, a variable T2, a variable T3, a variable E1, a variable V1 and a variable V2-are initialized by setting values of the variables to zero. Then the processing advances to step 208. Hence, steps 208, 210, 212, 214 and 216 (steps 208 to 216) are the same as in the first exemplary embodiment, so will not be described. In the present exemplary embodiment, when the determination of step 216 is positive, the processing advances to step 252.

[0176] In step 252, a speed V_k relating to rotation of the image forming drum 44 is detected on the basis of the total duration $E1$ and the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signals. More specifically, in step 252, the peripheral face speed V_k of the image forming drum 44 is detected by dividing the movement distance ($R_0\theta_0$) of the peripheral face of the image forming drum 44 through the rotation angle θ_0 by the total duration $E1$, as in the following equation (13).

$$V_k = (R_0\theta_0)/E1 \quad \text{Equation (13)}$$

[0177] Herein, step 252 corresponds to a speed detection section of a speed calculation component.

[0178] Then, in step 254, the value of variable $V1$ is updated by putting the value of variable $V2$ into variable $V1$, and the value of variable $V2$ is updated by putting the value of variable V_k into variable $V2$.

[0179] Next, in step 256, by judging whether or not all the values of variable $V1$ and variable $V2$ are greater than zero, it is determined whether or not information that will be required when calculating a speed in step 258, details of which are described below, is all present.

[0180] In step 256, if it is judged that there is a variable among all the variables of variable $V1$ and variable $V2$ whose value is zero, it is determined that not all the information that would be required when calculating the speed in step 258 whose details are described below is present, and the processing returns to step 208. On the other hand, if it is judged in step 256 that the values of all the variables of variable $V1$ and variable $V2$ are greater than zero, it is determined that all the information that will be required when calculating the speed in step 258 whose details are described below is present, and the processing advances to the next step 258.

[0181] In step 258, a speed relating to rotation of the image forming drum 44 that is to be detected subsequent to the speed relating to rotation of the image forming drum 44 that has been currently detected in step 252 is calculated by estimation, by linear extrapolation on the basis of the pre-specified second number ($V1$ and $V2$ being two in the present exemplary embodiment) of speeds relating to rotation of the image forming drum 44 (peripheral face speeds in the present exemplary embodiment), as in the following equation (14). More specifically, in step 258, a peripheral face speed V of the image forming drum 44 to be detected subsequent to the peripheral face speed V_k of the image forming drum 44 that has been detected in step 252 at the current time is calculated by estimation, on the basis of the pre-specified second number of peripheral face speeds $V1$ and $V2$, as in the following equation (14).

$$V = 3*V2-2*V1 \quad \text{Equation (14)}$$

[0182] In step 258, the peripheral face speed V may be estimated as in the following equation (15).

$$V = 4*V2-3*V1 \quad \text{Equation (15)}$$

[0183] Herein, steps 254, 256 and 258 (steps 254 to 258) correspond to the speed detection section of the speed calculation component.

[0184] Then, in step 260, the value of the peripheral face speed V calculated in step 258 is outputted (reported) to the CPU 70. Then the processing advances to step 222.

[0185] The speed calculation device of the image forming device 10 of the present exemplary embodiment as described above, each time a rise or fall is detected in step 210, calculates, in step 214, the duration of the total $E1$ of the durations ($T0$ to $T3$ and $T1$ to $T4$) representing detection intervals of rises and falls that have been detected in the pre-specified first number ($T0$, $T1$, $T2$ and $T3$ being four and $T1$, $T2$, $T3$ and $T4$ being four) prior to the current rise or fall detected in step 210. A speed relating to rotation of the image forming drum 44 (the peripheral face speed in the present exemplary embodiment) is detected in step 252 on the basis of the calculated total duration $E1$ and the rotation angle θ_0 , and after the pre-specified number ($V1$ and $V2$ being two in the present exemplary embodiment) of speeds relating to rotation of the image forming drum 44 have been detected in step 252 (i.e., when the determination in step 256 is positive), a speed relating to rotation of the image forming drum 44 that will be detected in step 252 is calculated by estimation in step 258.

- Sixth Exemplary Embodiment -

[0186] Next, a sixth exemplary embodiment will be described. Portions of the present exemplary embodiment that are the same as in the first exemplary embodiment, the second exemplary embodiment, the third exemplary embodiment, the fourth exemplary embodiment and the fifth exemplary embodiment are assigned the same reference numerals and will not be described.

[0187] In the present exemplary embodiment, programs for executing the image formation control processing shown in Fig. 13 and the speed calculation processing shown in Fig. 17 are memorized in the ROM 72 in advance, the CPU 70 reads the program from the ROM 72 and executes the image formation control processing shown in Fig. 13, and the FPGA 79 reads the program from the ROM 72 and executes the speed calculation processing shown in Fig. 17.

[0188] Now the speed calculation processing that is executed by the FPGA 79 of the present exemplary embodiment will be described referring to Fig. 17.

[0189] Steps 201, 202 and 204 (steps 201 to 204) are the same as in the third exemplary embodiment, so will not be described. In the present exemplary embodiment, after step 204 the processing advances to step 261.

[0190] In step 261, variables-a variable i , a variable T_0 , a variable T_1 , a variable T_2 , a variable T_3 , a variable E_1 , a variable W_1 and a variable W_2 -are initialized by setting values of the variables to zero. Then the processing advances to step 208. Hence, steps 208, 210, 212, 214 and 216 (steps 208 to 216) are the same as in the first exemplary embodiment (or the third exemplary embodiment), so will not be described. In the present exemplary embodiment, when the determination of step 216 is positive, the processing advances to step 262.

[0191] In step 262, a speed W_k relating to rotation of the image forming drum 44 is detected on the basis of the total duration E_1 and the rotation angle θ_0 of the image forming drum 44 that corresponds to one pulse of the pulse signals. More specifically, in step 262, the speed W_k of the rotation of the image forming drum 44 is detected by dividing the rotation angle θ_0 by the total duration E_1 , as in the following equation (16).

$$W_k = \theta_0 / E_1$$

Equation (16)

[0192] Herein, step 262 corresponds to the speed detection section of the speed calculation component.

[0193] Then, in step 264, the value of variable W_1 is updated by putting the value of variable W_2 into variable W_1 , and the value of variable W_2 is updated by putting the value of variable W_k into variable W_2 .

[0194] Next, in step 266, by judging whether or not all the values of variable W_1 and variable W_2 are greater than zero, it is determined whether or not information that will be required when calculating a speed in step 268, details of which are described below, is all present.

[0195] In step 266, if it is judged that there is a variable among all the variables of variable W_1 and variable W_2 whose value is zero, it is determined that not all the information that would be required when calculating the speed in step 268 whose details are described below is present, and the processing returns to step 208. On the other hand, if it is judged in step 266 that the values of all the variables of variable W_1 and variable W_2 are greater than zero, it is determined that all the information that will be required when calculating the speed in step 268 whose details are described below is present, and the processing advances to the next step 268.

[0196] In step 268, a speed relating to rotation of the image forming drum 44 that is to be detected subsequent to the speed W_k relating to rotation of the image forming drum 44 that has been currently detected in step 262 is calculated by estimation, by linear extrapolation on the basis of the pre-specified second number (W_1 and W_2 being two in the present exemplary embodiment) of speeds relating to rotation of the image forming drum 44 (angular speeds in the present exemplary embodiment), as in the following equation (17). More specifically, in step 268, an angular speed W of the image forming drum 44 to be detected subsequent to the angular speed W_k that has been detected in step 262 at the current time is calculated by estimation, on the basis of the pre-specified second number of angular speeds W_1 and W_2 , as in the following equation (17).

$$W = 3 * W_2 - 2 * W_1$$

Equation (17)

[0197] In step 268, the angular speed W may be estimated as in the following equation (18).

$$W = 4 * W2 - 3 * W1$$

Equation (18)

[0198] Steps 264, 266 and 268 (steps 264 to 268) correspond to the speed detection section of the speed calculation component.

[0199] Then, in step 270, the value of the angular speed W calculated in step 268 is outputted (reported) to the CPU 70. Then the processing advances to step 222.

[0200] The speed calculation device of the image forming device 10 of the present exemplary embodiment as described above, each time a rise or fall is detected in step 210, calculates, in step 214, the duration of the total $E1$ of the durations ($T0$ to $T3$ and $T1$ to $T4$) representing detection intervals of rises and falls that have been detected in the pre-specified first number ($T0$, $T1$, $T2$ and $T3$ being four and $T1$, $T2$, $T3$ and $T4$ being four) prior to the current rise or fall detected in step 210. A speed relating to rotation of the image forming drum 44 (the angular speed W_k in the present exemplary embodiment) is detected in step 262 on the basis of the calculated total duration $E1$ and the rotation angle θ_0 , and after the pre-specified number ($W1$ and $W2$ being two in the present exemplary embodiment) of speeds relating to rotation of the image forming drum 44 have been detected in step 262 (i.e., when the determination in step 266 is positive), a speed relating to rotation of the image forming drum 44 that will be detected in step 262 is calculated by estimation in step 268.

[0201] In the exemplary embodiments described above (the first exemplary embodiment, the second exemplary embodiment, the third exemplary embodiment, the fourth exemplary embodiment, the fifth exemplary embodiment and the sixth exemplary embodiment), examples are described in which the present invention is applied to calculating a speed (the peripheral face speed V or the angular speed W) relating to rotation of the image forming drum 44 which serves as the rotating body in the image forming device 10 with the structure illustrated in Fig. 1. However, the present invention is not to be limited thus. For example, the present invention may be applied when calculating speeds of rotating bodies. For example, the present invention may be applied to a case of detecting a conveyance speed of a conveyance belt 328, by calculating a speed (a peripheral face speed or an angular speed) of a driving roller 324 which serves as a rotating body in an image forming device 312 as illustrated in Fig. 18, and altering a period P of a clock signal in accordance with the conveyance speed, or the like.

[0202] Now, general structure of the image forming device 312 illustrated in Fig. 18 will be described. As is shown in Fig. 18, a paper supply tray 316 is provided at a lower portion of the interior of a casing 314 of the image forming device 312, and recording paper W that is stacked in the paper supply tray 316 may be taken out one sheet at a time by a pickup roller 318. The recording paper W that is taken out is conveyed by plural conveyance roller pairs 320 which constitute a predetermined conveyance path 322. Herebelow, where simply "the conveyance direction" is referred to, this means a conveyance direction of the recording paper W , and where "upstream" and "downstream" are referred to, these mean upstream and downstream, respectively, in the conveyance direction.

[0203] The conveyance belt 328 is provided above the paper supply tray 316 in an endless form spanning between the driving roller 324 and a driven roller 326. The driving roller 324 receives driving force from the motor 30 and rotates. The driving roller 324 is equipped with the rotary encoder 52.

[0204] A recording head array 330 is disposed above the conveyance belt 328, opposing a flat portion 328F of the conveyance belt 328. This opposing region is an ejection region SE at which ink drops are ejected from the recording head array 330. The recording paper W that has been conveyed along the conveyance path 322 is retained at the conveyance belt 328 and reaches the ejection region SE, and in a state in which the recording paper W opposes the recording head array 330, ink droplets from the recording head array 330 are applied thereto in accordance with image information.

[0205] Then, by the recording paper W being conveyed in the state of being retained at the conveyance belt 328, the recording paper W passes through the interior of the ejection region SE and image formation may be performed. The recording paper W may be passed through the interior of the ejection region SE a plural number of times by being circulated in the state in which the recording paper W is retained at the conveyance belt 328. Thus, image formation with "multipassing" may be performed.

[0206] At the recording head array 330, four inkjet recording heads 332, corresponding to four respective colors Y , M , C and K , are arranged along the conveyance direction, effective recording regions thereof having long strip forms of at least the width of the recording paper W (i.e., the length in a direction orthogonal to the conveyance direction). Thus, full-color images may be formed. The inkjet recording heads 332 have the same constitution as the inkjet recording heads 48 described in the first exemplary embodiment, and similarly to the inkjet recording heads 48, include the nozzles 48a. Operations of the inkjet recording heads 332 are controlled by the recording head controller 84 described in the first exemplary embodiment.

[0207] A charging roller 335, to which a power supply is connected, is disposed at the upstream side of the recording head array 330. The charging roller 335 nips and is driven by the conveyance belt 328 and the recording paper W

between the charging roller 335 and the driving roller 324, and is formed to be movable between a pressing position, which presses the recording paper W against the conveyance belt 328, and a withdrawn position, which is withdrawn from the conveyance belt 328. When at the pressing position, the charging roller 335 provides electronic charge to the recording paper W and causes the recording paper W to be electrostatically adhered to the conveyance belt 328.

[0208] A separation plate 340, which is formed with an aluminium plate or the like, is disposed at the downstream side of the recording head array 330. The separation plate 340 is capable of separating the recording paper W from the conveyance belt 328. The separated recording paper W is conveyed by plural ejection roller pairs 342, which constitute an ejection path 344 at the downstream side of the separation plate 340, and is ejected to an ejection tray 346 disposed at an upper portion of the casing 314.

[0209] A cleaning roller 348, which is capable of nipping the conveyance belt 328 against the driven roller 326, is disposed below the separation plate 340. The surface of the conveyance belt 328 is cleaned by the cleaning roller 348.

[0210] An inversion path 352, which is constituted by plural inversion roller pairs 350, is provided between the paper supply tray 316 and the conveyance belt 328. The inversion path 352 inverts recording paper W at one face of which image formation has been performed, and causes the recording paper W to be retained at the conveyance belt 328.

Thus, image formation on both faces of the recording paper W is implemented with ease.

[0211] Ink tanks 354, which respectively store inks of the four colors, are disposed between the conveyance belt 328 and the ejection tray 346. The inks in the ink tanks 354 are supplied to the recording head array 330 by ink supply piping. Thus, structure of the image forming device 312 has been described with reference to Fig. 18.

[0212] Furthermore, in the exemplary embodiments described above, examples have been described which employ the rotary encoder 52 that generates two pulse signals with phase A and phase B. However, an encoder may be employed that generates more numerous pulse signals in order to improve the measurement frequency. For example, an encoder 55 illustrated in Fig. 19 may be employed, which is equipped with eight detectors around a code wheel. If this encoder 55 is employed, tracking of variations in speed is further improved and clock signals for printing (image formation) are generated with higher accuracy.

[0213] Further, in the exemplary embodiments described above, the inkjet recording heads 48 or 332 are constituted with the plural nozzles 48a being lined up in two rows with respect to the sub-scanning direction. However, the present invention is not to be limited thus. The constitutions of the inkjet recording heads 48 or 332 may be any constitution as long as the plural nozzles 48a are two-dimensionally arranged without overlapping in the sub-scanning direction.

[0214] Further, the exemplary embodiments described above have been described giving examples of image forming devices of modes which form images directly on recording paper W with the inkjet recording heads. However, the present invention is not to be limited thus. Image forming devices of modes that form images on recording paper W via intermediate transfer bodies are also possible. Such cases may be exemplified by an image forming device of a mode in which a latent image is formed on a peripheral face (a predetermined face) of a photosensitive drum, which is a rotating body, by recording heads that are provided with light-emitting elements such as LEDs or the like, the latent image is converted to a toner image, and the toner image is transferred onto a surface of a recording paper.

[0215] In addition, the structures of the image forming devices 10 and 312 described in the above exemplary embodiments are examples, and may be modified in accordance with circumstances within a technical scope not departing from the spirit of the present invention.

[0216] Further, the mathematical formulae described in the above exemplary embodiments are examples. Unnecessary parameters may be removed and new parameters may be added.

[0217] Further, the various processing programs described in the above exemplary embodiments are examples. Within a technical scope not departing from the spirit of the present invention, unnecessary steps may be removed, new steps may be added, and processing sequences may be rearranged.

- Seventh Exemplary Embodiment -

[0218] Fig. 1 is a structural diagram illustrating structure of a rotary encoder relating to a seventh exemplary embodiment. As shown in Fig. 1, the paper supply conveyance section 12 that supplies and conveys recording paper W, which is a recording medium, is provided at the image forming device 10. At the conveyance direction downstream side of the paper supply conveyance section 12, the processing fluid application section 14, the image formation section 16, the drying section 18, the image fixing section 20 and the ejection conveyance section 24 are provided along the conveyance direction of the recording paper W. The processing fluid application section 14 applies the processing fluid to the recording face (front face) of the recording paper W. The image formation section 16 forms an image on the recording face of the recording paper W. The drying section 18 dries the image that has been formed at the recording face. The image fixing section 20 fixes the dried image to the recording paper W. The ejection conveyance section 24 conveys the recording paper W to which the image has been fixed to the ejection section 22.

[0219] The paper supply conveyance section 12 is provided with the accommodation section 26 that accommodates the recording paper W, and the motor 30 is provided at the accommodation section 26. The paper supply apparatus is

also provided at the accommodation section 26, and the recording paper W is fed out from the accommodation section 26 toward the processing fluid application section 14 by the paper supply apparatus.

[0220] The processing fluid application section 14 is provided with the intermediate conveyance drum 28A and the processing fluid application drum 36. The intermediate conveyance drum 28A is rotatably disposed in a region sandwiched between the accommodation section 26 and the processing fluid application drum 36. The belt 32 spans between the rotation axle of the intermediate conveyance drum 28A and the rotation axle of the motor 30. Accordingly, rotary driving force of the motor 30 is transmitted to the intermediate conveyance drum 28A via the belt 32, and the intermediate conveyance drum 28A rotates in the direction of arrow A.

[0221] The retention member 34 that nips a distal end portion of the recording paper W and retains the recording paper W is provided at the intermediate conveyance drum 28A. The recording paper W that is fed out from the accommodation section 26 to the processing fluid application section 14 is retained at the peripheral face of the intermediate conveyance drum 28A by the retention member 34, and is conveyed to the processing fluid application drum 36 by the rotation of the intermediate conveyance drum 28A.

[0222] Similarly to the intermediate conveyance drum 28A, the retention members 34 are provided at the intermediate conveyance drums 28B, 28C, 28D and 28E, the processing fluid application drum 36, the image forming drum 44, the ink drying drum 56, the image fixing drum 62 and the ejection conveyance drum 68, which are described below. The recording paper W is passed along from upstream side drums to downstream side drums by these retention members 34.

[0223] A rotation axle of the processing fluid application drum 36 is linked with the rotation axle of the intermediate conveyance drum 28A by gears, and receives rotary force from the intermediate conveyance drum 28A and rotates.

[0224] The recording paper W that has been conveyed by the intermediate conveyance drum 28A is taken up onto the processing fluid application drum 36 by the retention member 34 of the processing fluid application drum 36, and is conveyed in the state of being retained at the outer peripheral face of the processing fluid application drum 36.

[0225] At the upper portion of the processing fluid application drum 36, the processing fluid application roller 38 is disposed in the state of touching against the outer peripheral face of the processing fluid application drum 36, and the processing fluid is applied to the recording face of the recording paper W on the outer peripheral face of the processing fluid application drum 36 by the processing fluid application roller 38.

[0226] The recording paper W to which the processing fluid has been applied by the processing fluid application section 14 is conveyed to the image formation section 16 by the rotation of the processing fluid application drum 36.

[0227] The image formation section 16 is provided with the intermediate conveyance drum 28B and the image forming drum 44. The rotation axle of the intermediate conveyance drum 28B is linked with the rotation axle of the processing fluid application drum 36 by gears, and receives rotary force from the processing fluid application drum 36 and rotates.

[0228] The recording paper W that has been conveyed by the processing fluid application drum 36 is taken up onto the intermediate conveyance drum 28B by the retention member 34 of the intermediate conveyance drum 28B of the image formation section 16, and is conveyed in the state of being retained at the outer peripheral face of the intermediate conveyance drum 28B.

[0229] The rotation axle of the image forming drum 44, which serves as an image conveyance component, is linked with the rotation axle of the intermediate conveyance drum 28B by gears, and receives rotary force from the intermediate conveyance drum 28B and rotates.

[0230] The recording paper W that has been conveyed by the intermediate conveyance drum 28B is taken up onto the image forming drum 44 by the retention member 34 of the image forming drum 44, and is conveyed in the state of being retained at the outer peripheral face of the image forming drum 44.

[0231] Above the image forming drum 44, the head unit 46 is disposed close to the outer peripheral face of the image forming drum 44. The head unit 46 is provided with the four inkjet recording heads 48, corresponding to each of the four colors yellow (Y), magenta (M), cyan (C) and black (K). These inkjet recording heads 48 are arranged along the peripheral direction of the image forming drum 44, and form an image by ejecting ink droplets from the nozzles 48a, which will be described later, synchronously with clock signals, which will be described later, such that the ink droplets are superposed with the layer of processing fluid that has been formed on the recording face of the recording paper W by the processing fluid application section 14.

[0232] The image forming drum 44 is provided with the rotary encoder 52, which will be described in more detail later. The rotary encoder 52, in accordance with the rotation of the image forming drum 44, generates a pulse signal for detecting a pre-specified rotation reference position of the image forming drum 44 and plural pulse signals with phase differences, which are pulse signals for detecting rotation angles from the pre-specified rotation reference position of the image forming drum 44.

[0233] As illustrated by the example in Fig. 20, the rotary encoder 52 relating to the present seventh exemplary embodiment is structured to include a circular plate-form code wheel 53, which serves as a rotating body, and a pulse signal generation section 55, which serves as a generation component. The code wheel 53 is fixed to the image forming drum 44 such that a central portion thereof is disposed at a central portion of the image forming drum 44. Plural slits 53A, which serve as detected portions, are formed in the code wheel 53, extending outward in radial directions from the

central portion and arranged at equidistant intervals along the circumferential direction. The pulse signal generation section 55 senses the slits 53A and generates the plural pulse signals with phase differences. The pulse signal generation section 55 relating to the seventh exemplary embodiment is constituted with an A-phase transmission-type photosensor and a B-phase transmission-type photosensor. The A-phase transmission-type photosensor is structured with a light emission element and a light detection element that are disposed so as to face one another sandwiching the code wheel 53, detects the slits 53A and generates an A-phase pulse signal. The B-phase transmission-type photosensor is structured with a light emission element and a light detection element that are disposed so as to face one another sandwiching the code wheel 53, detects the slits 53A and generates a B-phase pulse signal.

[0234] In the seventh exemplary embodiment, the spacing between adjacent slits 53A formed in the code wheel 53 corresponds to a reference rotation angle θ_0 of the code wheel 53 (for example, 1.257 milliradians).

[0235] In the code wheel 53, a reference slit is provided closer to the central portion than the plural slits 53A. The reference slit is for detecting a rotation reference position of the code wheel 53 that corresponds to the pre-specified rotation reference position of the image forming drum 44. A transmission-type photosensor is provided at a housing of the image forming device 10, separately from the transmission-type photosensors that constitutes the pulse signal generation section 55, for detecting the reference slit.

[0236] The recording paper W on which the image has been formed at the recording face by the image formation section 16 is conveyed to the drying section 18 by the rotation of the image forming drum 44.

[0237] The drying section 18 is provided with the intermediate conveyance drum 28C and the ink drying drum 56. The rotation axle of the intermediate conveyance drum 28C is linked with the rotation axle of the image forming drum 44 by gears, and receives rotary force from the image forming drum 44 and rotates.

[0238] The recording paper W that has been conveyed by the image forming drum 44 is taken up onto the intermediate conveyance drum 28C by the retention member 34 of the intermediate conveyance drum 28C, and is conveyed in the state of being retained at the outer peripheral face of the intermediate conveyance drum 28C.

[0239] The rotation axle of the ink drying drum 56 is linked with the rotation axle of the intermediate conveyance drum 28C by gears, and receives rotary force from the intermediate conveyance drum 28C and rotates.

[0240] The recording paper W that has been conveyed by the intermediate conveyance drum 28C is taken up onto the ink drying drum 56 by the retention member 34 of the ink drying drum 56, and is conveyed in the state of being retained at the outer peripheral face of the ink drying drum 56.

[0241] Above the ink drying drum 56, the hot air heater 58 is disposed close to the outer peripheral face of the ink drying drum 56. Excess solvent in the image that has been formed on the recording paper W is removed by hot air from the hot air heater 58. The recording paper W at which the image on the recording face has been dried by the drying section 18 is conveyed to the image fixing section 20 by the rotation of the ink drying drum 56.

[0242] The image fixing section 20 is provided with the intermediate conveyance drum 28D and the image fixing drum 62. The rotation axle of the intermediate conveyance drum 28D is linked with the rotation axle of the ink drying drum 56 by gears, and receives rotary force from the ink drying drum 56 and rotates.

[0243] The recording paper W that has been conveyed by the ink drying drum 56 is taken up onto the intermediate conveyance drum 28D by the retention member 34 of the intermediate conveyance drum 28D, and is conveyed in the state of being retained at the outer peripheral face of the intermediate conveyance drum 28D.

[0244] The rotation axle of the image fixing drum 62 is linked with the rotation axle of the intermediate conveyance drum 28D by gears, and receives rotary force from the intermediate conveyance drum 28D and rotates.

[0245] The recording paper W that has been conveyed by the intermediate conveyance drum 28D is taken up onto the image fixing drum 62 by the retention member 34 of the image fixing drum 62, and is conveyed in the state of being retained at the outer peripheral face of the image fixing drum 62.

[0246] At the upper portion of the image fixing drum 62, the fixing roller 64 with the heater therein is provided in the state in which pressing against or being separated from the outer peripheral face of the image fixing drum 62 may be selected. The recording paper W retained at the outer peripheral face of the image fixing drum 62 is nipped between the outer peripheral face of the image fixing drum 62 and the outer peripheral face of the fixing roller 64 and is heated by the heater in the state in which the recording paper W is pressed against the fixing roller 64. Thus, colorant in the image formed at the recording face of the recording paper W is fused to the recording paper W, and the image is fixed to the recording paper W. The recording paper W to which the image has been fixed by the image fixing section 20 is conveyed to the ejection conveyance section 24 by the rotation of the image fixing drum 62.

[0247] The ejection conveyance section 24 is provided with the intermediate conveyance drum 28E and the ejection conveyance drum 68. The rotation axle of the intermediate conveyance drum 28E is linked with the rotation axle of the image fixing drum 62 by gears, and receives rotary force from the image fixing drum 62 and rotates.

[0248] The recording paper W that has been conveyed by the image fixing drum 62 is taken up onto the intermediate conveyance drum 28E by the retention member 34 of the intermediate conveyance drum 28E, and is conveyed in the state of being retained at the outer peripheral face of the intermediate conveyance drum 28E.

[0249] The rotation axle of the ejection conveyance drum 68 is linked with the rotation axle of the intermediate con-

veyance drum 28E by gears, and receives rotary force from the intermediate conveyance drum 28E and rotates.

[0250] The recording paper W that has been conveyed by the intermediate conveyance drum 28E is taken up onto the ejection conveyance drum 68 by the retention member 34 of the ejection conveyance drum 68, and is conveyed toward the ejection section 22 in the state of being retained at the outer peripheral face of the ejection conveyance drum 68.

[0251] Fig. 2 is a front view illustrating structure of an inkjet ejection aperture face side of each inkjet recording head 48 relating to the seventh exemplary embodiment. As shown in Fig. 2, the nozzles 48a, which serve as plural image formation elements that respectively eject ink droplets, are formed in the face 90 of the inkjet recording head 48 that opposes the outer peripheral face of the image forming drum 44. Each inkjet recording head 48 has the structure in which the plural nozzles 48a are arranged two-dimensionally (in a staggered matrix pattern in the seventh exemplary embodiment) without overlapping in the direction of conveyance of the recording paper W by the image forming drum 44 (the sub-scanning direction). Thus, an increase in density of the effective nozzle spacing (projected nozzle pitch) as projected so as to lie along the head length direction (the direction orthogonal to the direction of conveyance of the recording paper W by the image forming drum 44 (which is below referred to simply as the conveyance direction)) is achieved.

[0252] In the inkjet recording head 48 relating to the seventh exemplary embodiment, the plural nozzles 48a are arranged with pre-specified spacings and are arrayed in nozzle groups of two rows, nozzle group A disposed at the conveyance direction upstream side and nozzle group B disposed at the conveyance direction downstream side. The nozzles 48a of nozzle group B are arranged so as to be disposed at spaces between the nozzles 48a of nozzle group A.

[0253] Fig. 3 is a block diagram illustrating principal structures of an electronic system of the image forming device 10 relating to the seventh exemplary embodiment.

[0254] The image forming device 10 is structured to include the CPU (central processing unit) 70, ROM (read-only memory) 72, RAM (random access memory) 74, NVM (non-volatile memory) 76, UI (user interface) panel 78, FPGA (field-programmable gate array) 79 and communication I/F (communication interface) 80. In the seventh exemplary embodiment, the apparatus including this computer and the rotary encoder 52 corresponds to a speed estimation device that includes a function of estimating a speed relating to rotation of the image forming drum 44 serving as the rotating body.

[0255] The CPU 70 administers operations of the image forming device 10 as a whole. The CPU 70 reads a program from the ROM 72 and executes image formation control processing.

[0256] The ROM 72 serves as a memory component at which are memorized beforehand: a program for executing the image formation control processing that controls operations of the image forming device 10, which is described in detail hereafter; the reference rotation angle θ_0 ; a distance from the axial center of the code wheel 53 (which corresponds to a center of the code wheel 53 in the seventh exemplary embodiment) to the outer peripheral face of the image forming drum 44 (referred to hereafter in the seventh exemplary embodiment as distance R_0), which corresponds to a rotation radius of the image forming drum 44; a distance between adjacent dots (herein, between centers of the dots; referred to hereafter in the present exemplary embodiment as distance X_0); and various parameters and the like. In the seventh exemplary embodiment, the radius of the image forming drum 44 is employed as the pre-specified distance R_0 , but this is not to be limiting and another value may be employed.

[0257] The RAM 74 is used as a work area during execution of various programs and the like. The NVM 76 memorizes various kinds of information that need to be retained when the power switch of the device is turned off.

[0258] The UI panel 78 is structured by a touch panel display, in which a transmissive touch panel is superposed on a display, or the like. The UI panel 78 displays various kinds of information at a display screen of the display, and inputs required information, instructions and the like in accordance with a user touching the touch panel.

[0259] The FPGA 79 reads a program from the ROM 72 and executes the speed estimation processing.

[0260] The communication interface 80 is connected with the terminal device 82, which is a personal computer or the like, and receives image information representing an image to be formed at the recording paper W and various other kinds of information from the terminal device 82.

[0261] The CPU 70, the ROM 72, the RAM 74, the NVM 76, the UI panel 78, the FPGA 79 and the communication interface 80 are connected to one another via a system bus. Therefore, the CPU 70 may implement each of access to the ROM 72, the RAM 74 and the NVM 76, display of various kinds of information at the UI panel 78, acquisition of details of control instructions from users from the UI panel 78, reception of various kinds of information from the terminal device 82 via the communication interface 80, and control of the FPGA 79.

[0262] The image forming device 10 is further provided with the recording head controller 84 and the motor controller 86.

[0263] The recording head controller 84 controls operations of the inkjet recording head 48 in accordance with instructions from the CPU 70. The motor controller 86 controls operations of the motor 30.

[0264] The recording head controller 84 and the motor controller 86 are also connected to the above-mentioned system bus. Thus, the CPU 70 may control operations of the recording head controller 84 and the motor controller 86.

[0265] The above-described rotary encoder 52 is also connected to the aforementioned system bus. Thus, the CPU 70 may receive the plural pulse signals generated by the rotary encoder 52.

[0266] Next, operation of the image forming device 10 relating to the seventh exemplary embodiment will be described.

[0267] In the image forming device 10 relating to the seventh exemplary embodiment, recording paper W is fed out from the accommodation section 26 to the intermediate conveyance drum 28A by the paper supply apparatus, the recording paper W is conveyed via the intermediate conveyance drum 28A, the processing fluid application drum 36 and the intermediate conveyance drum 28B to the image forming drum 44, and is retained at the outer peripheral face of the image forming drum 44. Then, ink droplets are ejected at the recording paper W on the image forming drum 44 from the nozzles 48a of the inkjet recording heads 48 in accordance with image information. Thus, an image represented by the image information is formed on the recording paper W.

[0268] Now, the conveyance speed of the recording paper W that is retained at the outer peripheral face of the image forming drum 44 varies as is shown by the example in the graph of Fig. 4 for reasons such as, for example, variations in meshing and loading of the driving system gears and variations in speed of the motor itself. The vertical axis of the graph in Fig. 4 shows the conveyance speed of the recording paper W at the image forming drum 44, and the horizontal axis shows the rotation angle of the image forming drum 44 from the pre-specified rotation reference position. Impact positions of ink dots that are formed to serve as constitutional units constituting the image, corresponding with the graph in Fig. 4, are shown by the solid line circles. The broken line circles show an example of impact positions of the ink droplets ejected from the nozzles 48a in a case in which the conveyance speed of the recording paper W is constant at a speed V.

[0269] In conditions in which the conveyance speed of the recording paper W at the image forming drum 44 varies in this manner, when the ink droplets are ejected from the nozzles 48a with the constant periodic spacing, the impact positions of the ink droplets are displaced. In order to suppress this, the rotary encoder 52 is attached to the image forming drum 44 and the pulse signals are generated by the rotary encoder 52 in accordance with conveyance speeds of the recording paper W retained at the outer peripheral face of the image forming drum 44. These pulse signals are outputted to the inkjet recording heads 48, ink droplets are ejected from the nozzles 48a synchronously with the conveyance speeds of the recording paper W, and the image is formed.

[0270] In order to suppress the deformation of images due to speed variations, estimating a conveyance speed of the recording paper W and altering the frequency of the clock signals in accordance with the conveyance speed may be considered. In order to estimate the conveyance speed of the recording paper W accurately, it is necessary to improve tracking of variations of the rotation speed of the image forming drum 44. Employing an apparatus that generates pulse signals with a higher frequency as the rotary encoder 52 may be considered for improving tracking of the variations in the rotation speed of the image forming drum 44. This is because it is thought that if the rotary encoder 52 that generates pulse signals with a higher frequency is employed, the detection interval of the rotation speed of the image forming drum 44 is shorter and the tracking of variations of the rotation speed of the image forming drum 44 improves. However, when the frequency is higher, the period of the pulse signals that are outputted from the rotary encoder 52 is shorter and measurement accuracy falls.

[0271] Accordingly, in the image forming device 10 relating to the seventh exemplary embodiment, in order to suppress deformation of an image due to variations in speed, the speed estimation processing is executed in order to improve tracking of variations in a speed relating to rotation of the image forming drum 44 and to estimate the speed relating to rotation of the image forming drum 44 with high accuracy.

[0272] Next, referring to Fig. 21, operations of the image forming device 10 relating to the seventh exemplary embodiment when the image formation control processing is executed for forming an image at the recording paper W will be described. Fig. 21 is a flowchart illustrating the flow of processing of an image formation control processing program that is executed by the CPU 70 when an instruction for execution of the image formation processing, and image information representing an image to be formed on the recording paper W, are inputted from the terminal device 82 via the communication I/F 80. In the image forming device 10 relating to the seventh exemplary embodiment, the image formation control processing program is memorized in advance at the ROM 72, which serves as a storage medium, but this is not to be limiting. Modes may be employed in which the image formation control processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM (compact disc ROM), a DVD-ROM (digital versatile disc ROM), a USB (universal serial bus) memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless.

[0273] In step 100A of Fig. 21, an instruction to start execution of the speed estimation processing relating to the seventh exemplary embodiment is outputted to the FPGA 79. Hence, the FPGA 79 performs control so as to start execution of the speed estimation processing relating to the seventh exemplary embodiment.

[0274] Now the speed estimation processing relating to the seventh exemplary embodiment that is executed by the FPGA 79 will be described referring to Fig. 22. Fig. 22 is a flowchart illustrating a flow of processing of a speed estimation processing program that is executed by the FPGA 79 when the instruction to start execution of the speed estimation processing relating to the seventh exemplary embodiment is inputted. In the image forming device 10 relating to the seventh exemplary embodiment, the speed estimation processing program is memorized in advance at the ROM 72 serving as a storage medium, but this is not to be limiting. Modes may be employed in which the speed estimation processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM,

DVD-ROM, USB memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless.

[0275] In step 200A of Fig. 22, the rotation angle θ_0 and the distance R_0 are read out from the ROM 72. Then, in step 202A, a rotation start instruction signal instructing the commencement of rotary driving of the image forming drum 44 is outputted to the motor controller 86. The motor controller 86 receiving the rotation start instruction signal causes the motor 30 to drive for rotation. Hence, the image forming drum 44 receives the rotary driving force from the motor 30 and starts to turn in a pre-specified rotation direction. In association therewith, the code wheel 53 also starts to turn in the pre-specified rotation direction.

[0276] Next, in step 204A, the processing waits until the image forming drum 44 reaches a pre-specified rotation speed (for example, 500 mm/s at the position separated from the center of the code wheel 53 by the distance R_0 corresponding to the rotation radius of the image forming drum 44). Here, the judgement in step 204A of whether or not the image forming drum 44 has reached the pre-specified rotation speed is determined by counting numbers of pulse signals generated by the rotary encoder 52 per unit time, but is not to be limited thereto. It may also be judged whether or not a pre-specified duration—a duration until the pre-specified rotation speed is reached and the rotation speed stabilizes—has passed since the image forming drum 44 started to rotate.

[0277] Then, in step 206A, variables—variable i , variable T_0 , variable T_1 , variable T_2 , variable T_3 and variable E_1 —are initialized by setting values of the variables to zero.

[0278] Next, in step 208A, timing by a timer is started, and a duration that has been measured at that point in time is put into the variable i . In the seventh exemplary embodiment, this timer measures durations in, for example, unit time intervals (for example, of 10 ns (nanoseconds)). More specifically, the duration is computed from a clock count of a counter implemented at the FPGA 79.

[0279] Then, in step 210A, pulse reversals, which is to say pulse rises and falls, of the respective pulses of the two pulse signals of phase A and phase B outputted from the rotary encoder 52 are detected for. Accordingly, when a pulse of either of the two pulse signals with phase A and phase B rises, the rise of the pulse of that signal is detected, and when a pulse of either of the two pulse signals with phase A and phase B falls, the fall of the pulse of that signal is detected. Herebelow, pulse rises and pulse falls are collectively referred to as pulse reversals.

[0280] Next, in step 212A, it is judged whether or not a pulse reversal has been detected in step 210A. If it is judged in step 212A that a pulse reversal has been detected in step 210A, the processing advances to the next step 214A. On the other hand, if it is judged in step 212A that no pulse reversal has been detected in step 210A, the processing returns to step 210A, and respective pulse reversals of the two pulse signals with phase A and phase B outputted from the rotary encoder 52 are again detected for.

[0281] In step 214A, the value of variable T_0 is updated by putting the value of variable T_1 into variable T_0 , the value of variable T_1 is updated by putting the value of variable T_2 into variable T_1 , the value of variable T_2 is updated by putting the value of variable T_3 into variable T_2 , and the value of variable T_3 is updated by putting the value of variable i into variable T_3 . Then the value of variable E_1 is updated by putting the sum of the value of variable T_0 , the value of variable T_1 , the value of variable T_2 and the value of variable T_3 ($T_0+T_1+T_2+T_3$) into variable E_1 . Then, initialization is performed by stopping the timing by the timer that started in step 208A and setting the value of variable i to zero. Here, if the detection of a pulse reversal in the most recent processing of step 210A is a first (initial) detection, the value of variable i that has been put into variable T_3 in the present step 214A is the duration from the present speed estimation processing starting until a first detection. If the detection of a pulse reversal in the most recent processing of step 210A is a second or subsequent detection, this value of variable i is the duration from the previous detection by the processing of step 210A to the current detection by the processing of step 210A. That is, in step 214A, each time a pulse reversal is detected in step 210A, the duration E_1 is calculated, which is a total of durations (T_0 , T_1 , T_2 and T_3) representing detection intervals of a pre-specified number of the pulse reversals (T_0 to T_3 being four thereof) prior to the current pulse reversal detected in step 210A. The pre-specified number is a number of pulse reversals of the pulse signals generated by the rotary encoder 52 that corresponds to rotation of the image forming drum 44 through the reference rotation angle θ_0 .

[0282] Then, in step 216A, by determining whether or not all the values of variable T_0 , variable T_1 , variable T_2 and variable T_3 are greater than zero, it is determined whether or not information that will be required when calculating a speed in step 218A, details of which are described below, is all present.

[0283] In step 216A, if it is judged that there is a variable among all the variables of variable T_0 , variable T_1 , variable T_2 and variable T_3 whose value is zero, it is determined that all the information that would be required when calculating the speed in step 218A whose details are described below is not present, and the processing returns to step 208A. On the other hand, if it is judged in step 216A that the values of all the variables of variable T_0 , variable T_1 , variable T_2 and variable T_3 are greater than zero, it is determined that all the information that will be required when calculating the speed in step 218A whose details are described below is present, and the processing advances to the next step 218A.

[0284] In step 218A, a speed relating to rotation of the image forming drum 44 is estimated by calculation on the basis of the total duration E_1 calculated in step 214A and the reference rotation angle θ_0 . More specifically, in step 218A, a linear speed at the position separated by the distance R_0 in the rotation radial direction of the image forming drum 44

from the center of the code wheel 53, which is to say an outer periphery speed V of the image forming drum 44, is estimated by dividing a movement distance ($R_0\theta_0$) of the outer peripheral face of the image forming drum 44 through the rotation angle θ_0 by the total duration $E1$, as in equation (1).

[0285] Then, in step 220A, the value of the outer periphery speed V calculated in step 218A is outputted (reported) to the CPU 70.

[0286] Next, in step 222A, it is judged whether or not an instruction to stop execution of the speed estimation processing has been received from the CPU 70. If it is judged in step 222A that an instruction to stop execution of the speed estimation processing has not been received, the processing returns to step 208A. On the other hand, if it is judged in step 222A that an instruction to stop execution of the speed estimation processing has been received, the present speed estimation processing program ends.

[0287] Now the description of the flowchart shown in Fig. 21 is resumed. In the next step 102A, it is determined whether or not a value of the outer periphery speed V has been received from the FPGA 79. The determination processing of step 102A is repeated until reception is determined. When reception is determined in step 102A, the processing advances to the next step 104A.

[0288] Then, in step 104A, the distance X_0 is read from the ROM 72, the outer periphery speed V estimated by the speed estimation processing is used to calculate, with equation (2), a period P of the clock signal that prescribes timings of ejections of ink droplets from the nozzles 48a, and the period of the clock signal is corrected by setting this period P as a new period of the clock signal to be used when ejecting ink droplets from the nozzles 48a.

[0289] Then, in step 106A, a clock signal with the period P provided by the above processing of step 104A is generated and instructions to eject ink droplets from the nozzles 48a are outputted to the recording head controller 84, synchronously with this clock signal, in accordance with the inputted image information. Hence, the recording head controller 84 controls the inkjet recording heads 48 so as to eject ink droplets from the nozzles 48a in accordance with the inputted image information, synchronously with the clock signal with the period P . Thus, the image represented by the image information is formed at the recording face of the recording paper W without being affected by variations in the conveyance speed of the recording paper W .

[0290] Next, in step 108A, it is judged whether or not image formation with the inputted image information has ended. If this judgement is negative, the processing returns to step 102A. On the other hand, if the judgement in step 108A is positive, the processing advances to the next step 110A. In step 110A, an instruction to stop execution of the speed estimation processing is outputted to the FPGA 79. Then, the present image formation control processing program ends.

[0291] In this seventh exemplary embodiment, a detection component corresponds to the processing of step 210A, a calculation component corresponds to the processing of step 214A, an estimation component corresponds to the processing of step 218A, and a correction component corresponds to the processing of step 104A.

- Eighth Exemplary Embodiment -

[0292] Next, an eighth exemplary embodiment will be described. Portions of this eighth exemplary embodiment that are the same as in the seventh exemplary embodiment are assigned the same reference numerals and will not be described.

[0293] In the seventh exemplary embodiment, an example is described in which the speed estimation processing program for executing the processing of the flowchart shown in Fig. 22 is memorized in advance in the ROM 72, and the FPGA 79 reads the program from the ROM 72 and executes the processing of the flowchart shown in Fig. 22. In the eighth exemplary embodiment, a speed estimation processing program for executing the processing of the flowchart shown in Fig. 23 is memorized in the ROM 72 in advance, and the FPGA 79 reads the program from the ROM 72 and executes the processing of the flowchart shown in Fig. 23.

[0294] Now the speed estimation processing relating to the eighth exemplary embodiment that is executed by the FPGA 79 of the eighth exemplary embodiment will be described referring to Fig. 23. Fig. 23 is a flowchart illustrating a flow of processing of a speed estimation processing program that is executed by the FPGA 79 when an instruction to start execution of the speed estimation processing relating to the eighth exemplary embodiment is inputted. In the image forming device 10 relating to the eighth exemplary embodiment, the speed estimation processing program is memorized in advance at the ROM 72 serving as a storage medium, but this is not to be limiting. Modes may be employed in which the speed estimation processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM, DVD-ROM, USB memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless. Steps in Fig. 23 that carry out processing the same as in the flowchart shown in Fig. 22 are assigned the same step numbers as in Fig. 22 and descriptions thereof will not be given. The description starts from step 204A.

[0295] When the judgement in step 204A of Fig. 23 is positive, the processing advances to step 207A. In step 207A, variables—a variable i , a variable $T0$, a variable $T1$, a variable $T2$, a variable $T3$, a variable $T4$, a variable $E1$ and a variable $E2$ —are initialized by setting the values of the variables to zero, and the processing advances to step 208A.

[0296] When the judgement in step 212A is positive, the processing advances to step 215A. In step 215A, the value of variable T0 is updated by putting the value of variable T1 into variable T0, the value of variable T1 is updated by putting the value of variable T2 into variable T1, the value of variable T2 is updated by putting the value of variable T3 into variable T2, the value of variable T3 is updated by putting the value of variable T4 into variable T3, and the value of variable T4 is updated by putting the value of variable i into variable T4. Then the value of variable E1 is updated by putting the sum of the value of variable T0, the value of variable T1, the value of variable T2 and the value of variable T3 ($T0+T1+T2+T3$) into variable E1, and the value of variable E2 is updated by putting the sum of the value of variable T1, the value of variable T2, the value of variable T3 and the value of variable T4 ($T1+T2+T3+T4$) into variable E2. Then, initialization is performed by stopping the timing by the timer that started in step 208A and setting the value of variable i to zero. Here, if the detection of a pulse reversal in the most recent processing of step 210A is the first (initial) detection, the value of variable i that has been put into variable T4 in the present step 215A is the duration from the present speed estimation processing starting until a first detection. If the detection of a pulse reversal in the most recent processing of step 210A is a second or subsequent detection, this value of variable i is the duration from the previous detection by the processing of step 210A to the current detection by the processing of step 210A. That is, in step 215A, each time a pulse reversal is detected in step 210A, the duration E1 is calculated, which is a total of durations (T0, T1, T2 and T3) representing detection intervals of a pre-specified number of the pulse reversals (T0 to T3 being four thereof) prior to the current pulse reversal detected in step 210A, in addition to which the duration E2 is calculated, which is a total of durations (T1, T2, T3 and T4) representing detection intervals of the pre-specified number of the pulse reversals (T1 to T4 being four thereof) prior to the current pulse reversal detected in step 210A. The pre-specified number is the number of pulse reversals of the pulse signals generated by the rotary encoder 52 in association with rotation of the image forming drum 44 through the reference rotation angle θ_0 .

[0297] Then, in step 217A, by determining whether or not all the values of variable T0, variable T1, variable T2, variable T3 and variable T4 are greater than zero, it is determined whether or not information that will be required when estimating a speed in step 221A, details of which are described below, is all present.

[0298] In step 217A, if it is judged that there is a variable among all the variables of variable T0, variable T1, variable T2, variable T3 and variable T4 whose value is zero, it is determined that all the information that would be required when estimating the speed in step 221A whose details are described below is not present, and the processing returns to step 208A. On the other hand, if it is judged in step 217A that the values of all the variables of variable T0, variable T1, variable T2, variable T3 and variable T4 are greater than zero, it is determined that all the information that will be required when estimating the speed in step 221A whose details are described below is present, and the processing advances to the next step 219A.

[0299] In step 219A, for the respective total durations E1 and E2 that have been calculated in step 215A, control is performed so as to memorize a pre-specified number (E1 and E2 being two in the eighth exemplary embodiment) of the total durations E1 and E2 in the NVM 76, which serves as a memory component, to serve as a history. Accordingly, the total durations E1 and E2 are memorized in the NVM 76.

[0300] Then, in step 22 1 A, a speed relating to rotation of the image forming drum 44 is calculated on the basis of, of the pre-specified number of total durations E1 and E2 memorized in the NVM 76, the pre-specified number of total durations E1 and E2 and the reference rotation angle θ_0 . More specifically, in step 221A a duration E, for estimating the speed relating to rotation of the image forming drum 44 (the outer periphery speed V in the eighth exemplary embodiment) that is to be estimated a next time, is estimated by linear extrapolation based on, of the pre-specified number of total durations E1 and E2 memorized in the NVM 76, the pre-specified number of total durations E1 and E2 (E1 and E2 being two in the eighth exemplary embodiment), and the outer periphery speed V of the image forming drum 44 is estimated by dividing the movement distance ($R_0\theta_0$) of the outer peripheral face of the image forming drum 44 through the reference rotation angle θ_0 by the duration E, as in equation (3). Then the processing advances to step 220A.

[0301] Now, the processing of step 22 1 A will be more specifically described with reference to Fig. 11.

[0302] As shown in Fig. 11, the period (total duration) represented by the most recent pulse signals from the rotary encoder 52 is E2, and the period (total duration) one step prior thereto is E1. The speed $V1 (= (R_0\theta_0)/E1)$ calculated with E1 is the average speed over t_1-t_5 , and the speed $V2 (= (R_0\theta_0)/E2)$ calculated with E2 is the average speed over t_2-t_6 . The duration E1 and the duration E2 correspond with the times t_3 and t_4 , respectively, and the speed V1 and the speed V2 correspond to speeds at the times t_3 and t_4 , respectively.

[0303] Given that the intervals t_i to t_{i+1} are substantially equal intervals, if the period at an intermediate point between t_6 and t_7 is the duration E, duration E is expressed by equation (20), derived from the following equation (19) by linear extrapolation. The speed to be estimated from E1 and E2 is the speed V at the intermediate point between t_6 and t_7 . The speed V at the intermediate point between t_6 and t_7 is represented by equation (4), derived from equation (3) and equation (20).

$$7:2 = (E-E1):(E2-E1)$$

Equation (19)

5

$$E = (7 \cdot E2 - 5 \cdot E1) / 2$$

Equation (20)

10 **[0304]** Now, in this eighth exemplary embodiment, because the pre-specified number that is applied is the number 2, the durations E1 and E2 are calculated in step 215A, but this is not to be limiting. For example, the pre-specified number that is applied may be the number 3. In such a case, as an example, a duration E3 is calculated in step 215A in addition to the durations E1 and E2. The duration E3 is a total of durations (T2, T3, T4 and T5) representing detection intervals of the pre-specified number of pulse reversals (T2 to T5). Thus, the pre-specified number may be any number as long as it is at least 2.

15 **[0305]** In step 221 A in the eighth exemplary embodiment, the speed relating to rotation of the image forming drum 44 is calculated on the basis of the pre-specified number of total durations E1 and E2 and the reference rotation angle θ_0 , but this is not to be limiting. For example, the pre-specified number that is applied may be 3, the durations E1 to E3 may be calculated in step 215A, and the speed relating to rotation of the image forming drum 44 may be calculated in step 221 A on the basis of any two of the durations E1, E2 and E3 and the reference rotation angle θ_0 .

20 **[0306]** The pre-specified number that is applied may be the number 4, with durations E1 to E4 being calculated in step 215A (E4 being the sum of durations T3 to T6), and the speed relating to rotation of the image forming drum 44 being calculated in step 221 A on the basis of an average value E1' of E1 and E2, an average value E2' of E3 and E4, and the reference rotation angle θ_0 . Thus, the speed relating to rotation of the image forming drum 44 may be calculated in step 221 A on the basis of the plural durations obtained by calculation in step 215A and the reference rotation angle θ_0 .

25 **[0307]** In the eighth exemplary embodiment, the calculation component corresponds to the processing of step 215A and the estimation component corresponds to the processing of step 221A.

- Ninth Exemplary Embodiment -

30 **[0308]** Next, a ninth exemplary embodiment will be described. Portions of this ninth exemplary embodiment that are the same as in the seventh and eighth exemplary embodiments are assigned the same reference numerals and will not be described.

35 **[0309]** In the seventh exemplary embodiment, an example is described in which the programs for executing the processing of the flowchart shown in Fig. 21 and the processing of the flowchart shown in Fig. 22 are memorized in advance in the ROM 72, the CPU 70 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 21, and the FPGA 79 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 22. In the ninth exemplary embodiment, an image formation control processing program for executing the processing of a flowchart shown in Fig. 24 and a speed estimation processing program for executing the processing of a flowchart shown in Fig. 25 are memorized in advance in the ROM 72, the CPU 70 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 24, and the FPGA 79 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 24 and Fig. 25.

40 **[0310]** Now the image formation control processing relating to the ninth exemplary embodiment that is executed by the CPU 70 will be described referring to Fig. 24. Fig. 24 is a flowchart illustrating a flow of processing of the image formation control processing program that is executed by the FPGA 79 when an instruction to start execution of the image formation control processing relating to the ninth embodiment is inputted. In the image forming device 10 relating to the ninth exemplary embodiment, the image formation control processing program is memorized in advance at the ROM 72 serving as a storage medium, but this is not to be limiting. Modes may be employed in which the image formation control processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM, DVD-ROM, USB memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless. Steps in Fig. 24 that carry out processing the same as in the flowchart shown in Fig. 21 are assigned the same step numbers as in Fig. 21 and descriptions thereof will not be given. The description starts from step 100A.

50 **[0311]** In step 100A of Fig. 24, an instruction to start execution of the speed estimation processing relating to the ninth exemplary embodiment is outputted to the FPGA 79. Hence, the FPGA 79 performs control so as to start execution of the speed estimation processing relating to the ninth exemplary embodiment.

55 **[0312]** Now the speed estimation processing relating to the ninth exemplary embodiment that is executed by the FPGA 79 of the ninth exemplary embodiment will be described referring to Fig. 25. Fig. 25 is a flowchart illustrating a flow of processing of the speed estimation processing program that is executed by the FPGA 79 when an instruction to start

execution of the speed estimation processing relating to the ninth exemplary embodiment is inputted. In the image forming device 10 relating to the ninth exemplary embodiment, the speed estimation processing program is memorized in advance at the ROM 72 serving as a storage medium, but this is not to be limiting. Modes may be employed in which the speed estimation processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM, DVD-ROM, USB memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless. Steps in Fig. 25 that carry out processing the same as in the flowchart shown in Fig. 22 are assigned the same step numbers as in Fig. 22 and descriptions thereof will not be given. Steps that differ from the steps of the flowchart shown in Fig. 22 will be described here.

[0313] In step 201A of Fig. 25, the rotation angle θ_0 is read from the ROM 72. Then the processing advances to step 202A.

[0314] In step 216A, if it is judged that all the values of variable T_0 , variable T1, variable T2 and variable T3 are greater than zero, (when the judgement is positive) it is determined that information that will be required when estimating a speed in step 230A, details of which are described below, is all present, after which the processing advances to step 230A.

[0315] In step 230A, a speed relating to rotation of the image forming drum 44 is estimated by calculation on the basis of the total duration E1 calculated in the earlier-described step 214A and the reference rotation angle θ_0 . More specifically, in step 230A, an angular speed W of the image forming drum 44 is calculated by dividing the reference rotation angle θ_0 by the duration E1, as in equation (8).

[0316] Then, in step 232A, the value of the angular speed W calculated in step 230A is outputted (reported) to the CPU 70. Then the processing advances to step 222A.

[0317] Now the description of the flowchart shown in Fig. 24 is resumed. In the next step 103A, it is determined whether or not a value of the angular speed W has been received from the FPGA 79. The determination processing of step 103A is repeated until reception is determined. When reception is determined in step 103A, the processing advances to the next step 105A.

[0318] Then, in step 105A, the distance R_0 and the distance X_0 are read from the ROM 72, the angular speed W estimated in the above speed estimation processing is used to calculate, with equation (9), a period P of the clock signal that prescribes timings of ejections of ink droplets from the nozzles 48a, the period of the clock signal is corrected by setting this period P as a new period of the clock signal to be used when ejecting ink droplets from the nozzles 48a, after which the processing advances to the next step 106A.

[0319] In the ninth exemplary embodiment, the estimation component corresponds to the processing of step 230A and the correction component corresponds to the processing of step 105A.

- Tenth Exemplary Embodiment -

[0320] Next, a tenth exemplary embodiment will be described. Portions of this tenth exemplary embodiment that are the same as in the seventh to ninth exemplary embodiments are assigned the same reference numerals and will not be described.

[0321] In the tenth exemplary embodiment, the image formation control processing program for executing the processing of the flowchart shown in Fig. 24 and the speed estimation processing program for executing processing of a flowchart shown in Fig. 26 are memorized in the ROM 72 in advance, the CPU 70 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 24, and the FPGA 79 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 26.

[0322] Now the speed estimation processing that is executed by the FPGA 79 of the tenth exemplary embodiment will be described referring to Fig. 26. Fig. 26 is a flowchart illustrating a flow of processing of the speed estimation processing program that is executed by the FPGA 79 when an instruction to start execution of the speed estimation processing relating to the tenth exemplary embodiment is inputted. In the image forming device 10 relating to the tenth exemplary embodiment, the speed estimation processing program is memorized in advance at the ROM 72 serving as a storage medium, but this is not to be limiting. Modes may be employed in which the speed estimation processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM, DVD-ROM, USB memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless.

[0323] Step 201A of Fig. 26 is the same as in the processing of the flowchart shown in Fig. 25, and steps 202A, 204A, 207A, 208A, 210A, 212A, 215A, 217A, 219A and 222A are the same as in the processing of the flowchart shown in Fig. 23, so will not be described.

[0324] In the tenth exemplary embodiment, after the processing of step 219A ends, the processing advances to step 240A. In step 240A, a speed relating to rotation of the image forming drum 44 is estimated by calculation on the basis of the pre-specified number of total durations E1 and E2 that have been memorized in the NVM 76 and the reference rotation angle θ_0 . More specifically, similarly to the eighth exemplary embodiment, in step 240A a duration E, for estimating the speed relating to rotation of the image forming drum 44 that is to be estimated a next time (the angular speed W of

the image forming drum 44 in this tenth exemplary embodiment), is estimated by linear extrapolation, based on the pre-specified number of the total durations E1 and E2 memorized in the NVM 76, and the angular speed W of the image forming drum 44 is estimated by dividing the reference rotation angle θ_0 by the duration E, as in equation (10). Then the processing advances to step 242A.

[0325] In step 242A, the value of the angular speed W calculated in step 240A is outputted (reported) to the CPU 70. Then the processing advances to step 222A and subsequent processing the same as in the eighth exemplary embodiment is carried out.

[0326] In the tenth exemplary embodiment, the estimation component corresponds to the processing of step 240A.

- Eleventh Exemplary Embodiment -

[0327] Next, an eleventh exemplary embodiment will be described. Portions of this eleventh exemplary embodiment that are the same as in the seventh to tenth exemplary embodiments are assigned the same reference numerals and will not be described.

[0328] In the eleventh exemplary embodiment, the image formation control processing program for executing the processing of the flowchart shown in Fig. 21 and the speed estimation processing program for executing processing of a flowchart shown in Fig. 27 are memorized in the ROM 72 in advance, the CPU 70 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 21, and the FPGA 79 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 27.

[0329] Now the speed estimation processing that is executed by the FPGA 79 of the eleventh exemplary embodiment will be described referring to Fig. 27. Fig. 27 is a flowchart illustrating a flow of processing of the speed estimation processing program that is executed by the FPGA 79 when an instruction to start execution of the speed estimation processing relating to the eleventh exemplary embodiment is inputted. In the image forming device 10 relating to the eleventh exemplary embodiment, the speed estimation processing program is memorized in advance at the ROM 72 serving as a storage medium, but this is not to be limiting. Modes may be employed in which the speed estimation processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM, DVD-ROM, USB memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless.

[0330] Steps 200A, 202A, 204A, 208A, 210A, 212A, 214A, 216A and 222A of Fig. 27 are the same as in the processing of the flowchart shown in Fig. 22, so will not be described.

[0331] When the judgement in step 204A of Fig. 27 is positive, the processing advances to step 250A. In step 250A, variables-a variable i, a variable T0, a variable T1, a variable T2, a variable T3, a variable E1, a variable V1 and a variable V2-are initialized by setting the values of the variables to zero, and the processing advances to step 208A.

[0332] When the judgement in step 216A is positive, the processing advances to step 252A. In step 252A, a speed V_k relating to rotation of the image forming drum 44 is estimated on the basis of the total duration E1 and the reference rotation angle θ_0 . More specifically, in step 252A, the outer periphery speed V_k of the image forming drum 44 is estimated by dividing the movement distance ($R_0\theta_0$) of the outer peripheral face of the image forming drum 44 through the reference rotation angle θ_0 by the total duration E1, as in equation (13).

[0333] Then, in step 254A, the value of variable V1 is updated by putting the value of variable V2 into variable V1, and the value of variable V2 is updated by putting the value of variable V_k into variable V2.

[0334] Next, in step 256A, by judging whether or not all the values of variable V1 and variable V2 are greater than zero, it is determined whether or not information that will be required when estimating a speed in step 258A, details of which are described below, is all present.

[0335] In step 256A, if it is judged that there is a variable among all the variables of variable V1 and variable V2 whose value is zero, it is determined that not all the information that would be required when estimating the speed in step 258A whose details are described below is present, and the processing returns to step 208A. On the other hand, if it is judged in step 256A that the values of all the variables of variable V1 and variable V2 are greater than zero, it is determined that all the information that will be required when estimating the speed in step 258A whose details are described below is present, and the processing advances to the next step 258A.

[0336] In step 258A, a speed relating to rotation of the image forming drum 44 subsequent to the speed relating to rotation of the image forming drum 44 that has been estimated in step 252A at the current time is estimated, by linear extrapolation on the basis of the pre-specified number (two in the eleventh exemplary embodiment) of speeds relating to rotation of the image forming drum 44 (outer periphery speeds in the eleventh exemplary embodiment), as in equation (14). More specifically, in step 258A, an outer periphery speed V of the image forming drum 44 subsequent to the outer periphery speed V_k of the image forming drum 44 that has been estimated for the current time in step 252A is estimated by calculation, on the basis of the pre-specified number of outer periphery speeds V1 and V2, as in equation (14). In step 258A, the outer periphery speed V may instead be estimated as in equation (15).

[0337] Then, in step 260A, the value of the outer periphery speed V calculated in step 258A is outputted (reported)

to the CPU 70. Then the processing advances to step 222A.

[0338] In the eleventh exemplary embodiment, a first speed estimation section corresponds to the processing of step 252A and a second speed estimation section corresponds to the processing of step 258A.

5 - Twelfth Exemplary Embodiment -

[0339] Next, a twelfth exemplary embodiment will be described. Portions of this twelfth exemplary embodiment that are the same as in the seventh to eleventh exemplary embodiments are assigned the same reference numerals and will not be described.

10 **[0340]** In the twelfth exemplary embodiment, the image formation control processing program for executing the processing of the flowchart shown in Fig. 24 and a speed estimation processing program for executing processing of a flowchart shown in Fig. 28 are memorized in the ROM 72 in advance, the CPU 70 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 24, and the FPGA 79 reads a program from the ROM 72 and executes the processing of the flowchart shown in Fig. 28.

15 **[0341]** Now the speed estimation processing that is executed by the FPGA 79 of the twelfth exemplary embodiment will be described referring to Fig. 28. Fig. 28 is a flowchart illustrating a flow of processing of the speed estimation processing program that is executed by the FPGA 79 when an instruction to start execution of the speed estimation processing relating to the twelfth exemplary embodiment is inputted. In the image forming device 10 relating to the twelfth exemplary embodiment, the speed estimation processing program is memorized in advance at the ROM 72 serving as
20 a storage medium, but this is not to be limiting. Modes may be employed in which the speed estimation processing program is provided having been saved on a storage medium readable by a computer, such as a CD-ROM, DVD-ROM, USB memory or the like, and modes may be employed in which the program is distributed through a communications component, by wire or by wireless.

25 **[0342]** Steps 201A, 202A, 204A, 208A, 210A, 212A, 214A, 216A and 222A of Fig. 28 are the same as in the processing of the flowchart shown in Fig. 25, so will not be described.

[0343] When the judgement in step 204A of Fig. 28 is positive, the processing advances to step 261A. In step 261A, variables-a variable i , a variable T_0 , a variable T_1 , a variable T_2 , a variable T_3 , a variable E_1 , a variable W_1 and a variable W_2 -are initialized by setting the values of the variables to zero, and the processing advances to step 208A.

30 **[0344]** When the judgement in step 216A is positive, the processing advances to step 262A. In step 262A, a speed W_k relating to rotation of the image forming drum 44 is estimated on the basis of the total duration E_1 and the reference rotation angle θ_0 . More specifically, in step 262A, the outer periphery speed V_k of the image forming drum 44 is estimated by dividing the reference rotation angle θ_0 by the total duration E_1 , as in equation (16).

[0345] Then, in step 264A, the value of variable W_1 is updated by putting the value of variable W_2 into variable W_1 , and the value of variable W_2 is updated by putting the value of variable W_k into variable W_2 .

35 **[0346]** Next, in step 266A, by judging whether or not all the values of variable W_1 and variable W_2 are greater than zero, it is determined whether or not information that will be required when estimating a speed in step 268A, details of which are described below, is all present.

40 **[0347]** In step 266A, if it is judged that there is a variable among all the variables of variable W_1 and variable W_2 whose value is zero, it is determined that not all the information that would be required when estimating the speed in step 268A whose details are described below is present, and the processing returns to step 208A. On the other hand, if it is judged in step 266A that the values of all the variables of variable W_1 and variable W_2 are greater than zero, it is determined that all the information that will be required when calculating the speed in step 268A whose details are described below is present, and the processing advances to the next step 268A.

45 **[0348]** In step 268A, a speed relating to rotation of the image forming drum 44 subsequent to the speed W_k relating to rotation of the image forming drum 44 that has been estimated in step 262A at the current time is estimated, on the basis of the pre-specified number (two in the twelfth exemplary embodiment) of speeds relating to rotation of the image forming drum 44 (angular speeds in the twelfth exemplary embodiment), as in equation (17). More specifically, in step 268A, an angular speed W of the image forming drum 44 subsequent to the angular speed W_k that has been estimated for the current time in step 262A is estimated by calculation, on the basis of the pre-specified number of angular speeds
50 W_1 and W_2 , as in equation (17). In step 268A, the outer angular speed W may instead be estimated as in equation (18).

[0349] Then, in step 270A, the value of the angular speed W calculated in step 268A is outputted (reported) to the CPU 70. Then the processing advances to step 222A.

[0350] In the twelfth exemplary embodiment, the first speed estimation section corresponds to the processing of step 262A and the second speed estimation section corresponds to the processing of step 268A.

55 **[0351]** In the seventh to twelfth exemplary embodiments, examples are presented and described in which a speed (the outer periphery speed V or the angular speed W) relating to rotation of the image forming drum 44, which serves as the rotating body in the image forming device 10 with the structure illustrated in Fig. 1, is estimated, and the period P of the clock signal is corrected in accordance with the estimated speed. However, this is not to be limiting. For example,

in the image forming device 312 as illustrated in Fig. 18, a conveyance speed of the conveyance belt 328 may be estimated, by estimating a speed (an outer periphery speed or an angular speed) of the driving roller 324, which serves as the rotating body, and correcting a period P of a clock signal in accordance with the estimated conveyance speed.

[0352] Furthermore, in the above-described seventh and ninth exemplary embodiments, examples have been presented in which the speed relating to rotation of the rotating body is estimated using the duration E1. However, this is not to be limiting. For example, the durations E1 and E2 may be calculated as described in the eighth exemplary embodiment and an outer periphery speed V (or angular speed W) that is the speed relating to rotation of the rotating body may be estimated using an average value of the durations E1 and E2. Thus, the speed relating to rotation of the rotating body may be estimated using an average value of a pre-specified number of durations.

[0353] In the seventh to twelfth exemplary embodiments described above, examples have been presented and described in which, each time a pulse reversal is detected, a total duration representing a detection interval of a pre-specified number of pulse reversals, which is a number of pulse reversals of the pulse signals generated by the rotary encoder 52 in association with rotation of the image forming drum 44 through the reference rotation angle θ_0 , prior to the current detection is calculated. However, this is not to be limiting. For example, each time a pulse reversal is detected, a duration required for detecting four pulse signal reversals over phase A and phase B prior to the current detection may be calculated on the basis of the detection intervals of the pulse signal reversals. In this case, the speed relating to rotation of the rotating body is estimated on the basis of the calculated duration and a rotation angle required for four reversals of the pulse signals over the phases. Further, in a case in which pulse signals in three phases or more are generated by the rotary encoder 52, a duration required for detecting six pulse signal reversals over phase A and phase B prior to the current detection may be calculated on the basis of the detection intervals of the pulse signal reversals. In this case, the speed relating to rotation of the rotating body is estimated on the basis of the calculated duration and a rotation angle required for six reversals of the pulse signals over the respective phases.

[0354] Thus, each time a pulse reversal is detected, a duration required for detecting a pre-specified number of pulse signal reversals over the phases prior to the current detection may be calculated on the basis of the detection intervals of the pulse signal reversals, and the speed relating to rotation of the rotating body may be estimated on the basis of the calculated duration and a rotation angle required for the pre-specified number of reversals of the pulse signals over the phases.

[0355] In the seventh to twelfth exemplary embodiments, examples are presented and described in which, by the speed estimation processing, processing is executed that estimates a speed relating to rotation of the image forming drum 44 and, by the image formation control processing, processing is executed that corrects the period P of the clock signal in accordance with the estimated speed. However, this is not to be limiting. Instead of processing that corrects the period P of the clock signal, processing may be executed in the image formation control processing that, by reference to the estimated speed, controls rotary driving of the image forming drum 44 via the motor controller 86 such that the outer periphery speed of the image forming drum 44 is at a pre-specified outer periphery speed.

[0356] In the seventh to twelfth exemplary embodiments, examples are presented and described in which a speed relating to rotation of the rotating body is estimated by calculation using an arithmetic equation. However, this is not to be limiting. For example, as a variant example of the seventh exemplary embodiment, a variant example may be presented in which a table in which the duration E1, the distance R_0 and the reference rotation angle θ_0 are inputs and the outer periphery speed V is the output is memorized in advance at a storage medium, such as the ROM 72 or the like, and the outer periphery speed V is estimated by derivation using this table. In the above described eighth to twelfth exemplary embodiments too, a table in which the values required for calculation of the speed relating to rotation of the rotating body are the inputs and the speed relating to rotation of the rotating body is the output may be memorized in advance at a storage medium such as the ROM 72 or the like, and the speed relating to rotation of the rotating body may be estimated by derivation using this table. Furthermore, a table in which the speed relating to rotation of the rotating body and the distance X_0 between the centers of neighboring dots are the inputs and the period P of the clock signal is the output may be memorized in advance at a storage medium such as the ROM 72 or the like, and the period P of the clock signal may be derived using this table.

[0357] In the seventh to twelfth exemplary embodiments, examples are presented and described of image forming devices of modes in which images are directly formed on recording paper W by the inkjet recording heads 48. However, this is not to be limiting. Image forming devices of modes that form images on recording paper W via intermediate transfer bodies are also possible. As an example of such cases, there is an image forming device of a mode in which a latent image is formed on an outer peripheral face (the pre-specified surface) of a photosensitive drum, which is the rotating body, by recording heads that are provided with light-emitting elements such as LEDs (light-emitting diodes) or the like, the latent image is converted to a toner image, and the toner image is transferred onto a recording face (surface) of recording paper.

[0358] In the seventh to twelfth exemplary embodiments, the inkjet recording heads 48 are constituted with the plural nozzles 48a being lined up in two rows without overlapping in the sub-scanning direction. However, this is not to be limiting. The constitution of the inkjet recording heads 48 may be any constitution as long as the plural nozzles 48a are

two-dimensionally arranged without overlapping in the sub-scanning direction.

[0359] In the exemplary embodiments described above, the distance R_0 is invariable, but this is not to be limiting and the distance R_0 may be variable. In such a case, a variant example may be mentioned in which the distance R_0 is altered in accordance with the thickness of the recording paper W at which an image is to be formed.

[0360] In the exemplary embodiments described above, transmission-type photosensors detect light amount variations and generate pulse signals in accordance with the light amount variations, but this is not to be limiting. For example, reflective plates with a greater optical reflectivity than other regions of the code wheel 53 may be provided instead of the slits 53A, and a reflection-type photosensor may be used instead of a transmission-type photosensor. The reflection-type photosensor is structured with a light-emitting element and a light detection element that detects light which has been emitted from the light-emitting element and reflected at the reflection plates. Thus, light amount variations may be detected and pulse signals generated by the reflection-type photosensor. Further, magnets may be provided instead of the slits 53A and, using a magnetism sensor instead of a photosensor, variations in magnetism may be detected and pulses generated by the magnetism sensor.

[0361] Thus, the rotary encoder 52 may be constituted to include: plural detected portions that are arranged at the code wheel 53 with equal spacings along the circumferential direction, and that are structured such that a particular physical characteristic thereof has a difference of at least a pre-specified magnitude from other regions of the code wheel 53; and a pulse signal generation portion that, in association with rotation of the code wheel 53, detects the difference in magnitude of the particular physical characteristic between the plural detected portions and regions of the code wheel 53 other than the detected portions and generates a pulse signal in accordance with the detected difference.

[0362] In the exemplary embodiments described above, examples have been presented and described of cases in which the image formation control processing program is executed by the CPU 70 and the speed estimation processing program is executed by the FPGA 79. However, this is not to be limiting. The image formation control processing program and the speed estimation processing program may both be executed by the CPU 70.

Claims

1. A speed calculation device comprising:

a generation component that generates a plurality of pulse signals with different phases in accordance with rotation of a rotating body;
a detection component that detects rises and falls of respective pulses of the plurality of pulse signals generated by the generation component;
a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified number of durations representing detection intervals of rises or falls detected prior to the rise or fall currently detected by the detection component; and
a speed calculation component that calculates a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals.

2. A speed calculation device comprising:

a generation component that generates a plurality of pulse signals with different phases in accordance with rotation of a rotating body;
a detection component that detects rises and falls of respective pulses of the plurality of pulse signals generated by the generation component;
a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified first number of durations representing detection intervals of rises or falls detected prior to the rise or fall currently detected by the detection component; and
a speed calculation component that calculates a speed relating to rotation of the rotating body on the basis of a pre-specified second number of the total durations calculated by the duration calculation component and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals.

3. A speed calculation device comprising:

a generation component that generates a plurality of pulse signals with different phases in accordance with rotation of a rotating body;
a detection component that detects rises and falls of respective pulses of the plurality of pulse signals generated by the generation component;

a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified first number of durations representing detection intervals of rises or falls detected prior to the rise or fall currently detected by the detection component; and

a speed calculation component that includes

a speed detection section that detects a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals, and

a speed calculation section that, after a pre-specified number of speeds have been detected by the speed detection section, calculates by estimation, on the basis of a pre-specified second number of the speeds relating to rotation of the rotating body that have been detected by the speed detection section, the speed relating to rotation of the rotating body that is to be detected subsequent to the speed relating to rotation of the rotating body currently detected by the speed detection section.

4. A program for causing a computer to function as:

a detection component that detects rises and falls of respective pulses of a plurality of pulse signals generated by a generation component, which generates the plurality of pulse signals with different phases in accordance with rotation of a rotating body;

a duration calculation component that, each time a rise or fall is detected by the detection component, calculates a total duration of a pre-specified first number of durations representing detection intervals of rises or falls detected by the detection component prior to the current rise or fall detected by the detection component; and a speed calculation component that includes

a speed detection section that detects a speed relating to rotation of the rotating body on the basis of the total duration and a rotation angle of the rotating body that corresponds to one pulse of the pulse signals,

and a speed calculation section that, after a pre-specified number of speeds have been detected by the speed detection section, calculates by estimation, on the basis of a pre-specified second number of the speeds relating to rotation of the rotating body that have been detected by the speed detection section, the speed relating to rotation of the rotating body that is to be detected subsequent to the speed relating to rotation of the rotating body currently detected by the speed detection section.

5. A speed estimation device comprising:

a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing;

a generation component that generates a plurality of pulse signals with different phases in accordance with passing of each of the plurality of detected portions in association with rotation of the rotating body;

a detection component that detects reversals of the pulse signals generated by the generation component;

a calculation component that, each time a reversal is detected by the detection component, calculates a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and

an estimation component that estimates a speed relating to rotation of the rotating body on the basis of the duration calculated by the calculation component and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases.

6. The speed estimation device of claim 5, wherein the estimation component estimates an angular speed of the rotating body, by calculating a ratio of the reference rotation angle to the duration calculated by the calculation component.

7. The speed estimation device of claim 5 or 6, wherein the estimation component estimates a linear speed at a position separated by a pre-specified distance in a rotation radial direction from a center of the rotating body, by calculating a ratio of a movement distance corresponding to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body to the duration calculated by the calculation component.

8. A speed estimation device comprising:

a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing;

a generation component that generates a plurality of pulse signals with different phases in accordance with

passing of each of the plurality of detected portions in association with rotation of the rotating body;
 a detection component that detects reversals of the pulse signals generated by the generation component;
 a calculation component that, each time a reversal is detected by the detection component, calculates a duration
 required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior
 to the current detection, on the basis of intervals of detection of the reversals; and
 an estimation component that estimates a speed relating to rotation of the rotating body on the basis of a plurality
 of the duration calculated by the calculation component and a reference rotation angle, which is a rotation angle
 required for the pre-specified number of reversals of the pulse signals over the respective phases.

9. The speed estimation device of claim 8, wherein the estimation component estimates the duration to be calculated
 by the calculation component a next time, on the basis of the plurality of durations, and estimates the speed relating
 to rotation of the rotating body on the basis of the estimated duration and the reference rotation angle.

10. The speed estimation device of claim 9, wherein the estimation component estimates the duration to be calculated
 by the calculation component the next time, on the basis of the plurality of durations, and estimates an angular
 speed of the rotating body, by calculating a ratio of the reference rotation angle to the estimated duration.

11. The speed estimation device of claim 9 or 10, wherein the estimation component estimates the duration to be
 calculated by the calculation component the next time, on the basis of the plurality of durations, and estimates a
 linear speed at a position separated by a pre-specified distance in a rotation radial direction from a center of the
 rotating body, by calculating a ratio of a movement distance corresponding to the reference rotation angle at the
 position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body
 to the estimated duration.

12. The speed estimation device of any of claims 8 to 11, wherein the plurality of durations is two durations, being the
 duration calculated by the calculation component at a current time and the duration calculated by the calculation
 component at a previous time.

13. A speed estimation device comprising:

a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a
 pre-specified rotation angle spacing;
 a generation component that generates a plurality of pulse signals with different phases in accordance with
 passing of each of the plurality of detected portions in association with rotation of the rotating body;
 a detection component that detects reversals of the pulse signals generated by the generation component;
 a calculation component that, each time a reversal is detected by the detection component, calculates a duration
 required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior
 to the current detection, on the basis of intervals of detection of the reversals; and
 an estimation component provided with
 a first speed estimation section that estimates a speed relating to rotation of the rotating body on the basis of
 the duration calculated by the calculation component and a reference rotation angle, which is a rotation angle
 required for the pre-specified number of reversals of the pulse signals over the respective phases, and
 a second speed estimation section that, after a plurality of the speed have been estimated by the first speed
 estimation section, estimates the speed relating to rotation of the rotating body subsequent to the speed estimated
 by the first speed estimation section at the current time, on the basis of the plurality of estimated speeds.

14. The speed estimation device of claim 13, wherein
 the first speed estimation section estimates an angular speed of the rotating body, by calculating a ratio of the
 reference rotation angle to the duration calculated by the calculation component, and
 the second speed estimation section, after a plurality of the angular speed have been estimated by the first speed
 estimation section, estimates an angular speed relating to rotation of the rotating body subsequent to the angular
 speed estimated by the first speed estimation section at the current time, on the basis of the plurality of estimated
 angular speeds.

15. The speed estimation device of claim 13 or 14, wherein
 the first speed estimation section estimates a linear speed at a position separated by a pre-specified distance in a
 rotation radial direction from a center of the rotating body, by calculating a ratio of a movement distance corresponding
 to the reference rotation angle at the position separated by the pre-specified distance in the rotation radial direction

from the center of the rotating body to the duration calculated by the calculation component, and the second speed estimation section, after a plurality of the linear speed have been estimated by the first speed estimation section, estimates a linear speed at the position separated by the pre-specified distance in the rotation radial direction from the center of the rotating body subsequent to the linear speed estimated by the first speed estimation section at the current time, on the basis of the plurality of estimated linear speeds.

16. An image forming device comprising:

a speed estimation device of any one of claims 5, 8 and 13;
 a recording head including a plurality of image forming elements that form constitutional units, which respectively constitute an image, at a pre-specified surface synchronously with a clock signal;
 an image conveyance component that conveys an image by causing the rotating body to function as one of a transfer body that transfers an image formed at a peripheral face thereof by the image forming elements to a surface of a recording medium and
 a conveyance body that, in a state in which a recording medium is retained at a peripheral face thereof, conveys the recording medium such that a surface of the recording medium opposes the image forming elements; and
 a correction component that corrects a period of the clock signal on the basis of the speed estimated by the estimation component and a distance between adjacent the constitutional units.

17. An image forming device comprising:

a speed estimation device of any one of claims 5, 8 and 13;
 a recording head including a plurality of image forming elements that form constitutional units, which respectively constitute an image, at a pre-specified surface;
 an image conveyance component that conveys an image by causing the rotating body to function as one of a transfer body that transfers an image formed at a peripheral face thereof by the image forming elements to a surface of a recording medium and
 a conveyance body that, in a state in which a recording medium is retained at a peripheral face thereof, conveys the recording medium such that a surface of the recording medium opposes the image forming elements; and
 a control component that, on the basis of the speed estimated by the estimation component, controls the rotation of the rotating body such that the speed relating to rotation of the rotating body is at a pre-specified speed.

18. A program of instructions executable by the computer to perform a function, the function comprising:

in association with rotation of a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing, detecting reversals of pulse signals generated by a generation component that generates a plurality of the pulse signals with different phases in accordance with passing of each of the plurality of detected portions;
 each time a reversal is detected, calculating a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and
 estimating a speed relating to rotation of the rotating body on the basis of the calculated duration and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases.

19. A program of instructions executable by the computer to perform a function, the function comprising:

in association with rotation of a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing, detecting reversals of pulse signals generated by a generation component that generates a plurality of the pulse signals with different phases in accordance with passing of each of the plurality of detected portions;
 each time a reversal is detected, calculating a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals; and
 estimating a speed relating to rotation of the rotating body on the basis of a plurality of the calculated duration and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases.

20. A program of instructions executable by the computer to perform a function, the function comprising:

5 in association with rotation of a rotating body provided with a plurality of detected portions that are arranged along a rotation direction with a pre-specified rotation angle spacing, detecting reversals of pulse signals generated by a generation component that generates a plurality of the pulse signals with different phases in accordance with passing of each of the plurality of detected portions;

each time a reversal is detected, calculating a duration required for detecting a pre-specified number of reversals of the pulse signals over the respective phases prior to the current detection, on the basis of intervals of detection of the reversals;

10 estimating a speed relating to rotation of the rotating body on the basis of the calculated duration and a reference rotation angle, which is a rotation angle required for the pre-specified number of reversals of the pulse signals over the respective phases; and

after a plurality of the speed have been estimated, estimating the speed relating to rotation of the rotating body subsequent to the speed estimated at the current time, on the basis of the plurality of estimated speeds.

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FIG.1

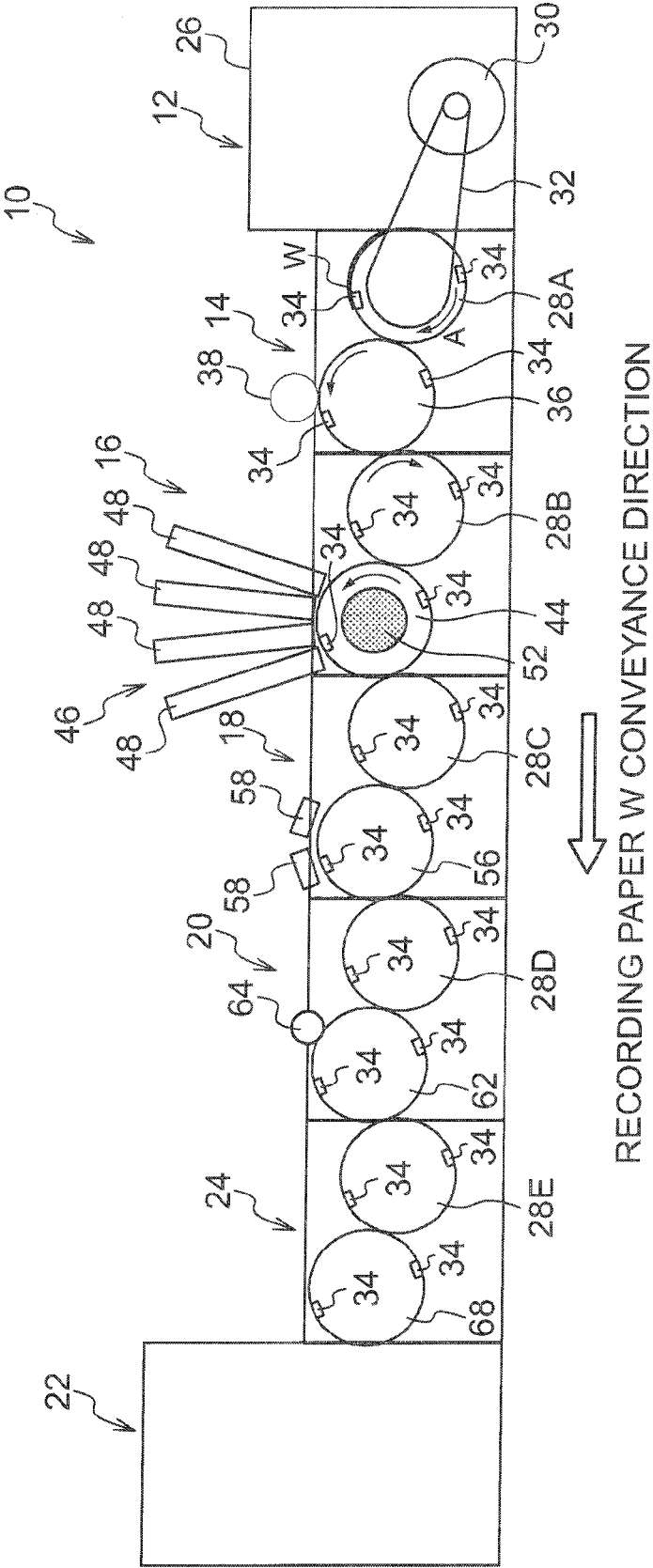


FIG.2

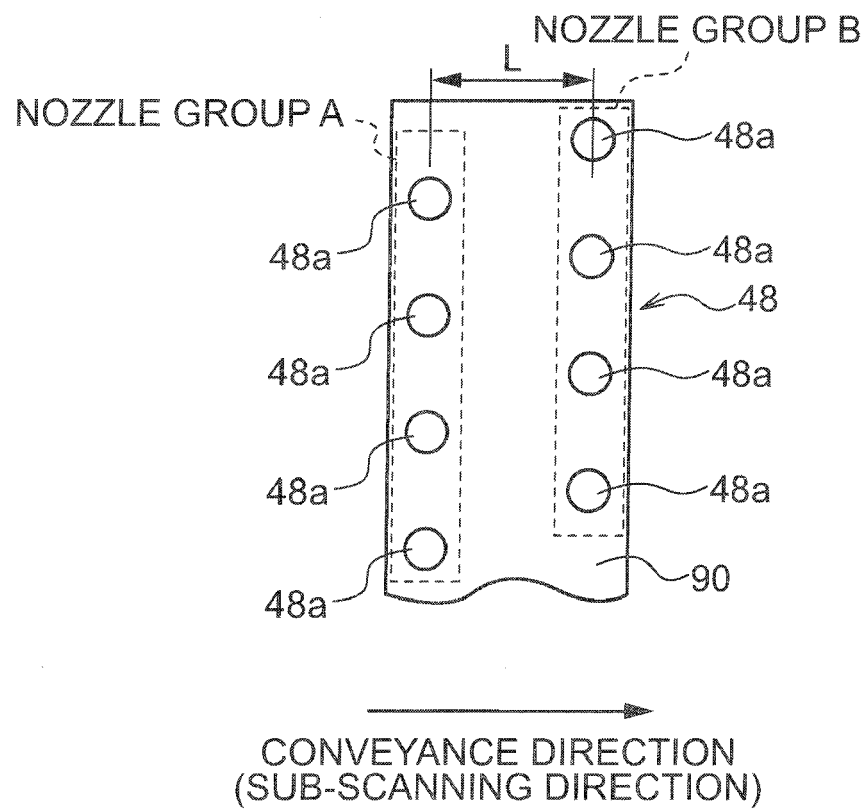


FIG.3

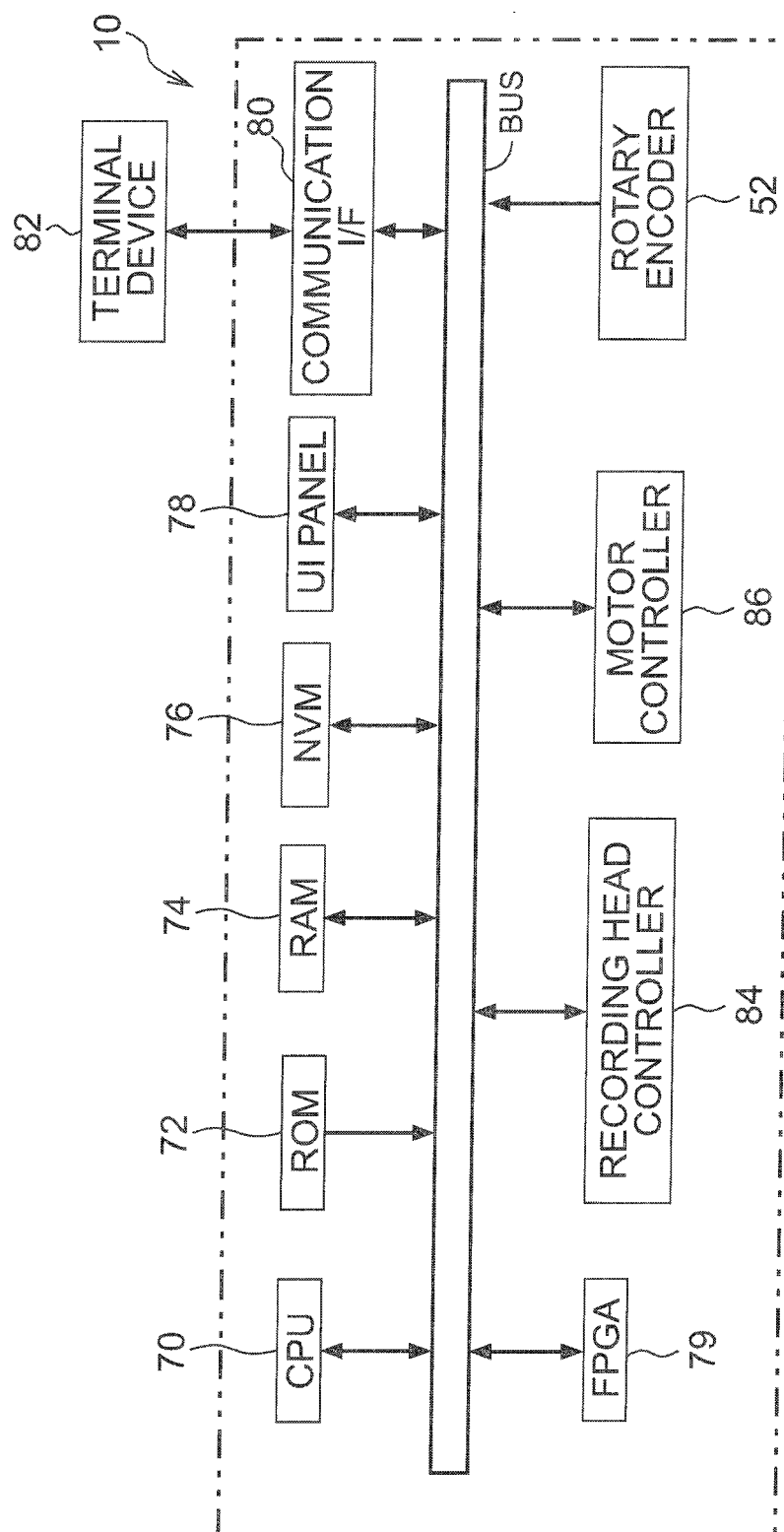


FIG.4

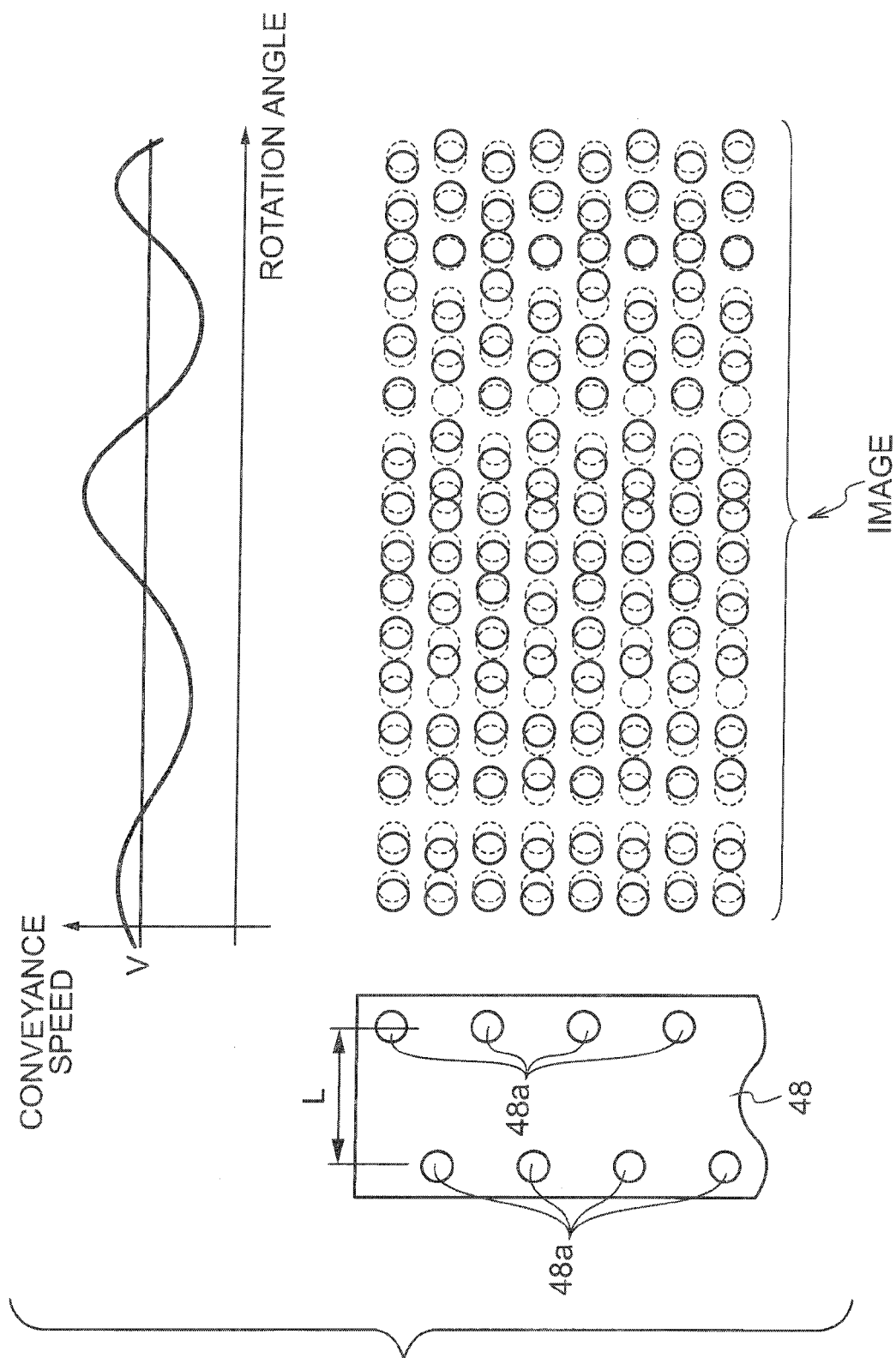


FIG.5

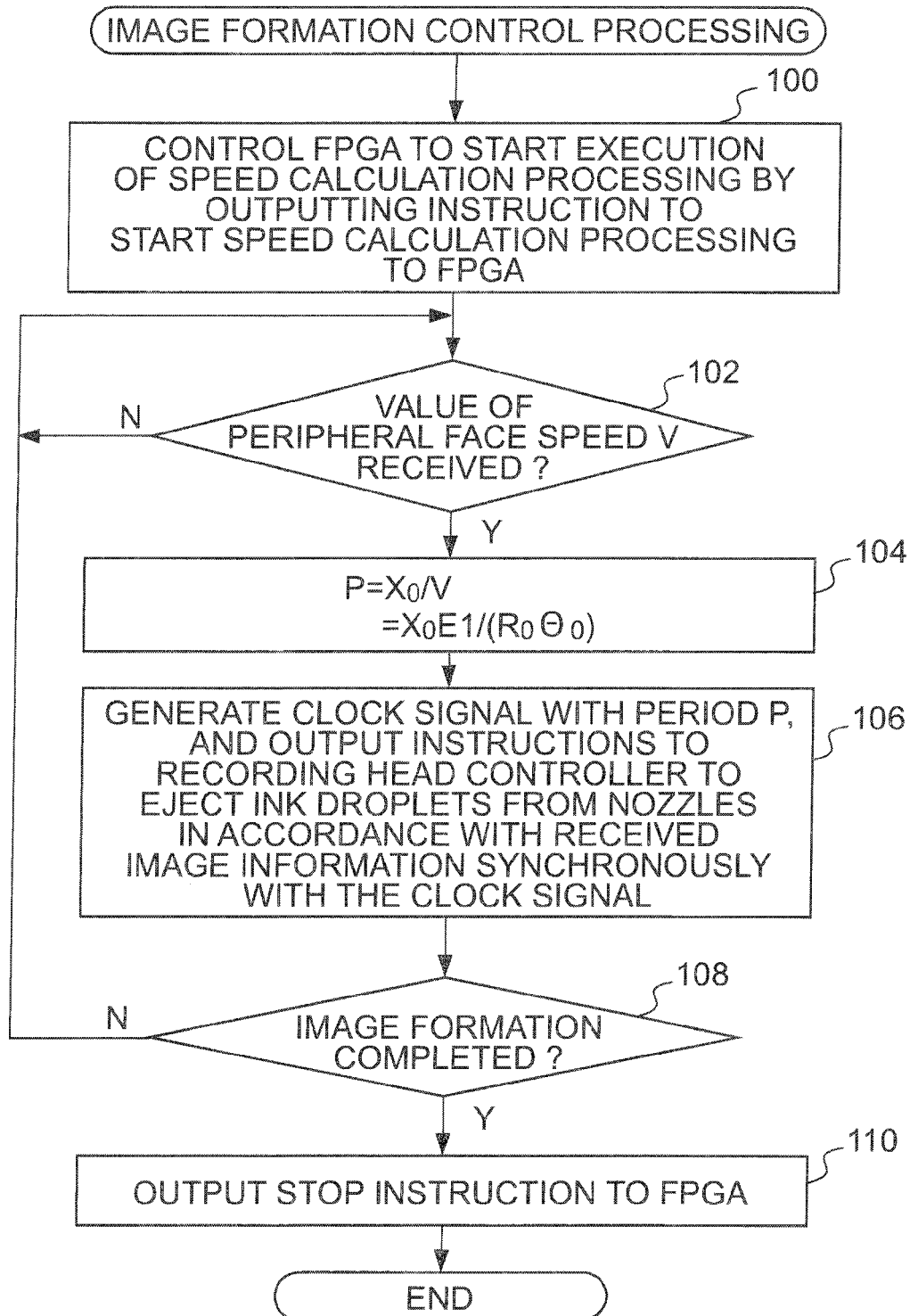


FIG.6

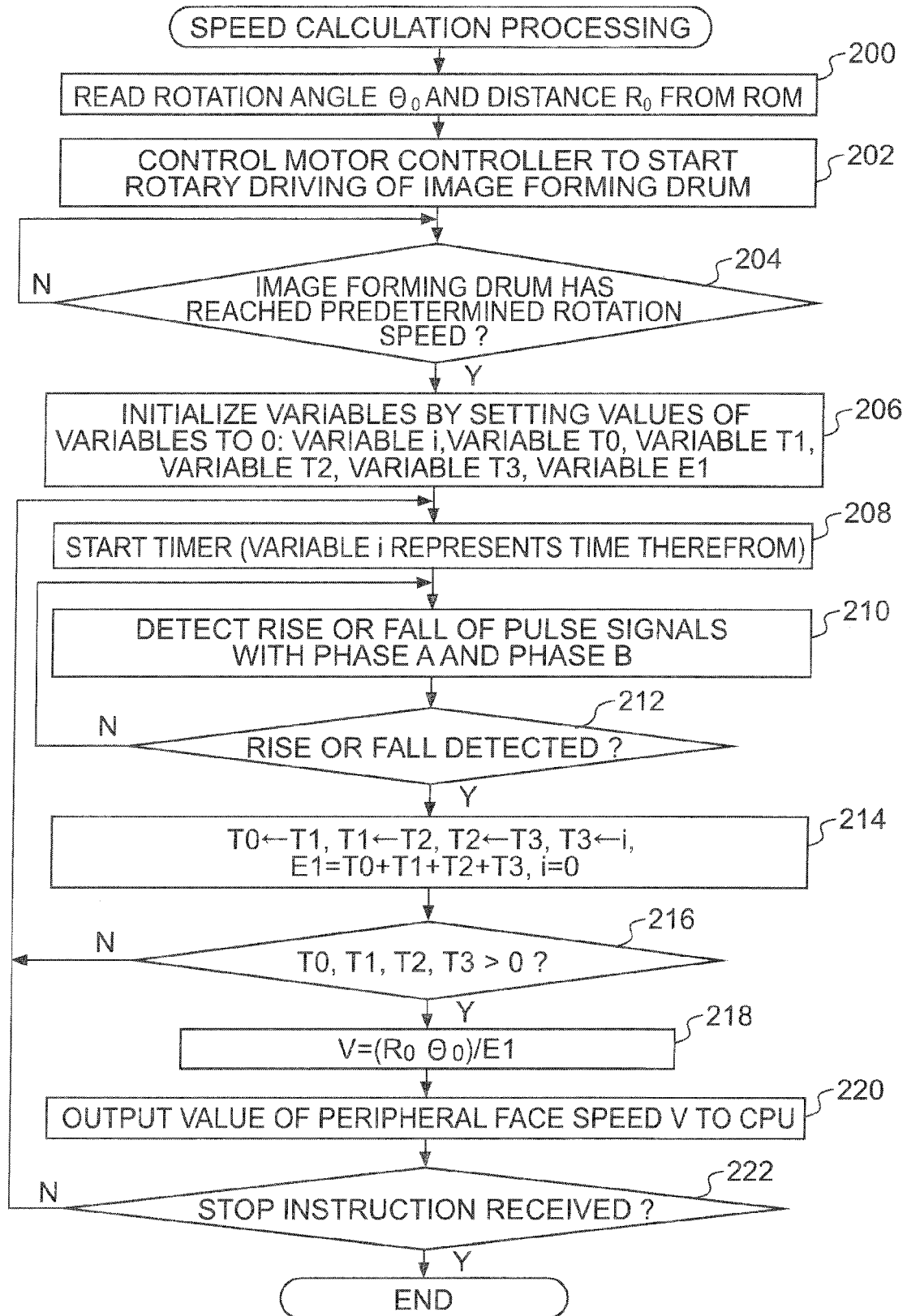


FIG.7A
RELATED ART

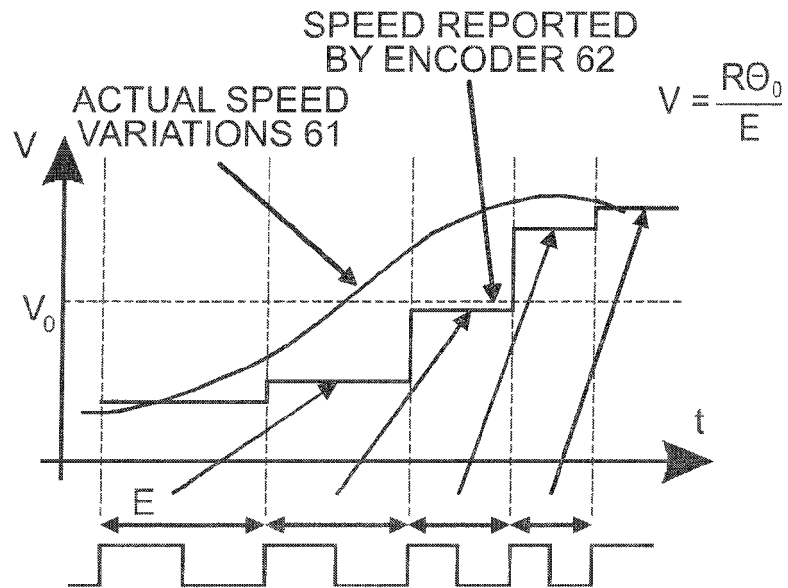


FIG.7B

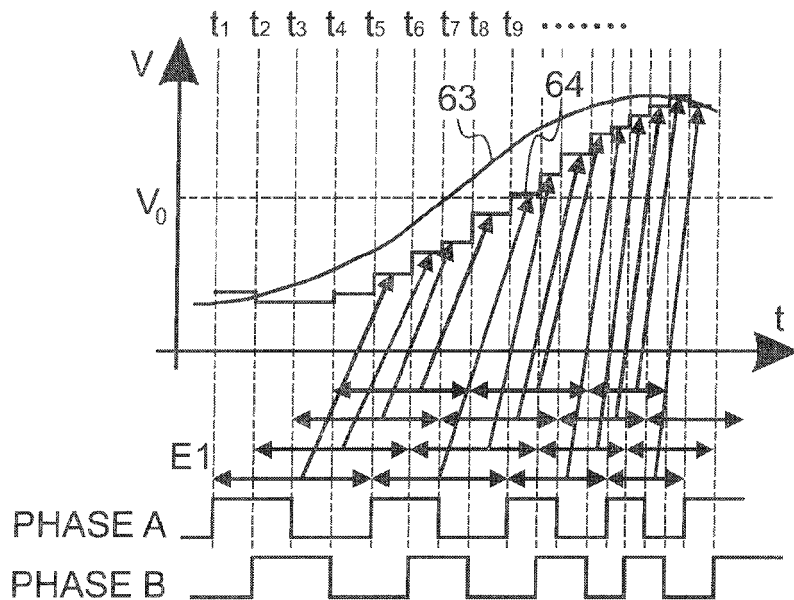


FIG.8

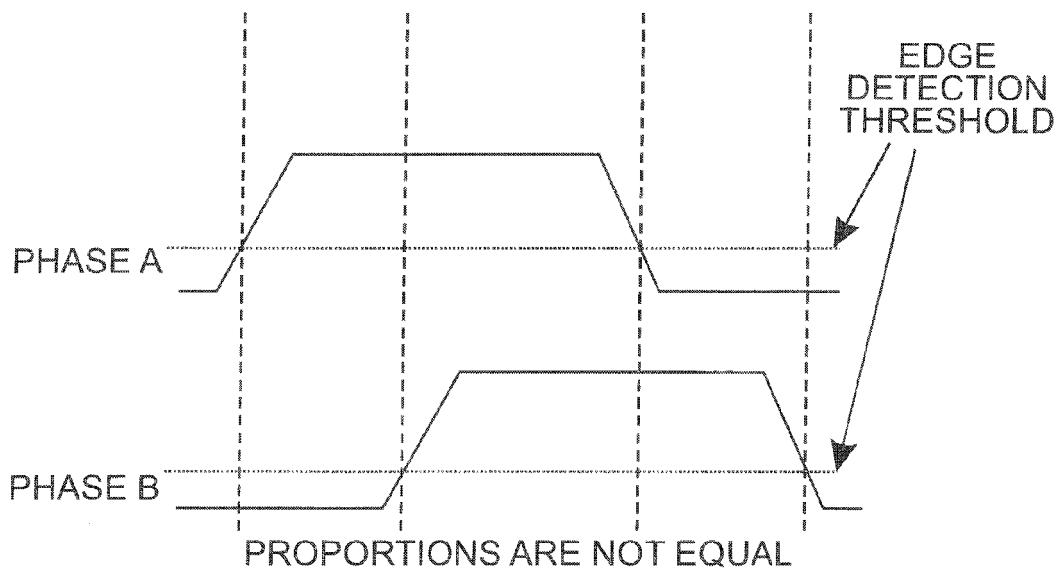


FIG.9

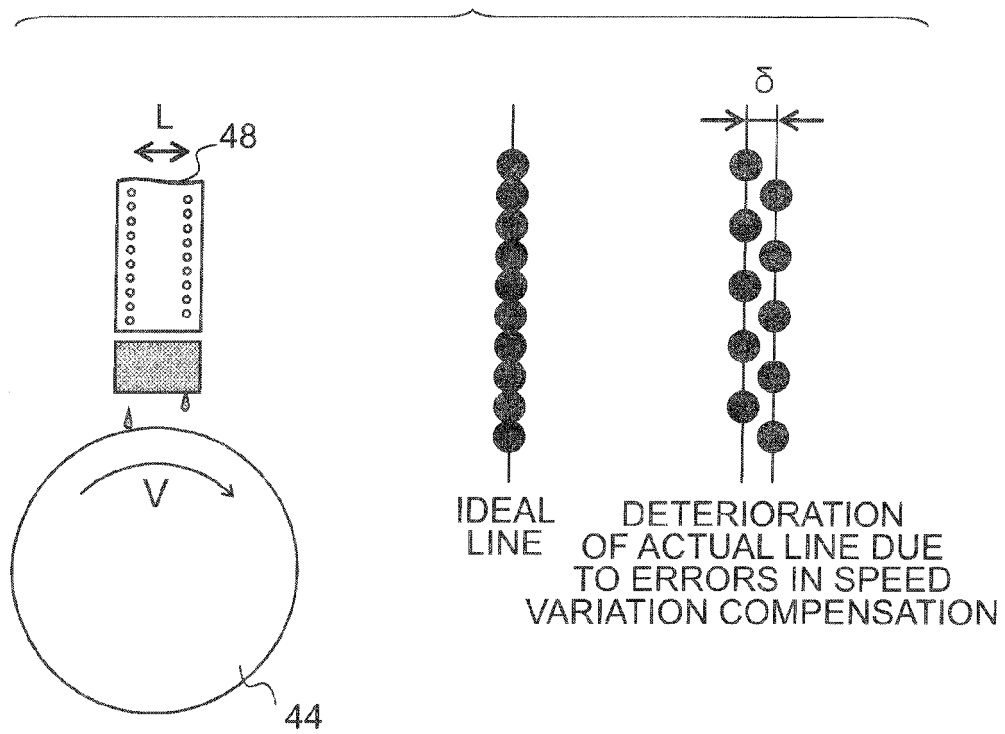


FIG.10

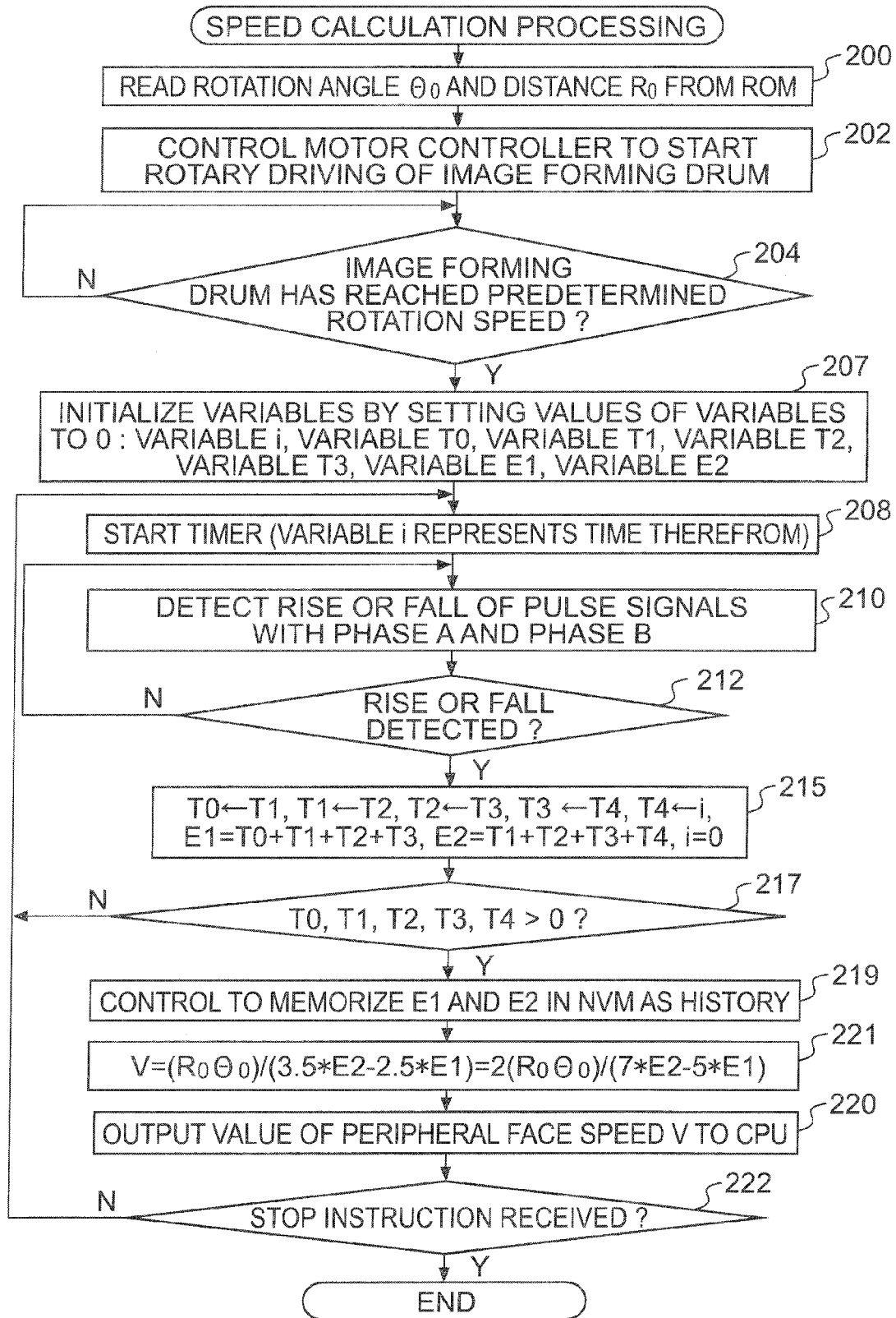


FIG.11

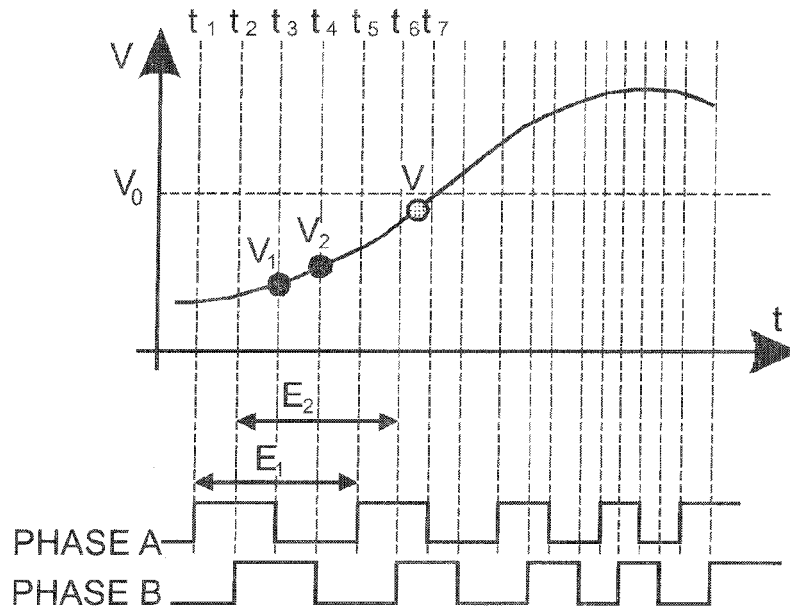


FIG.12

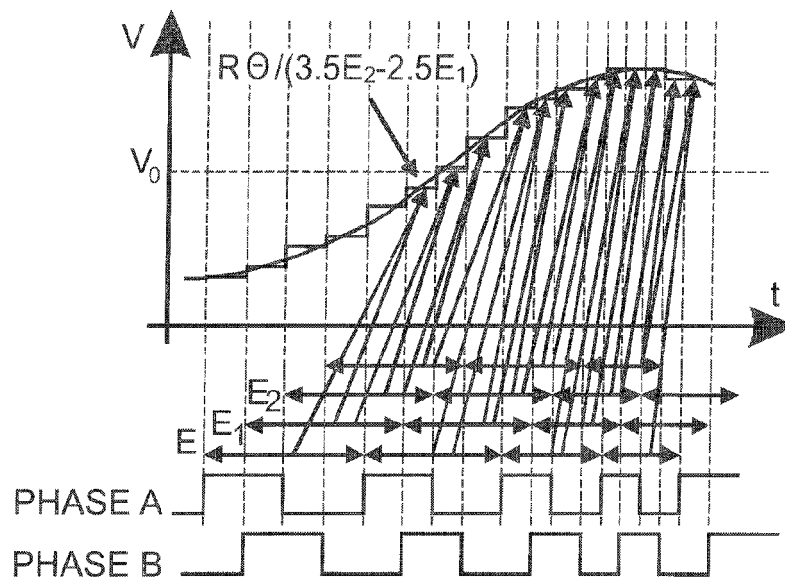


FIG.13

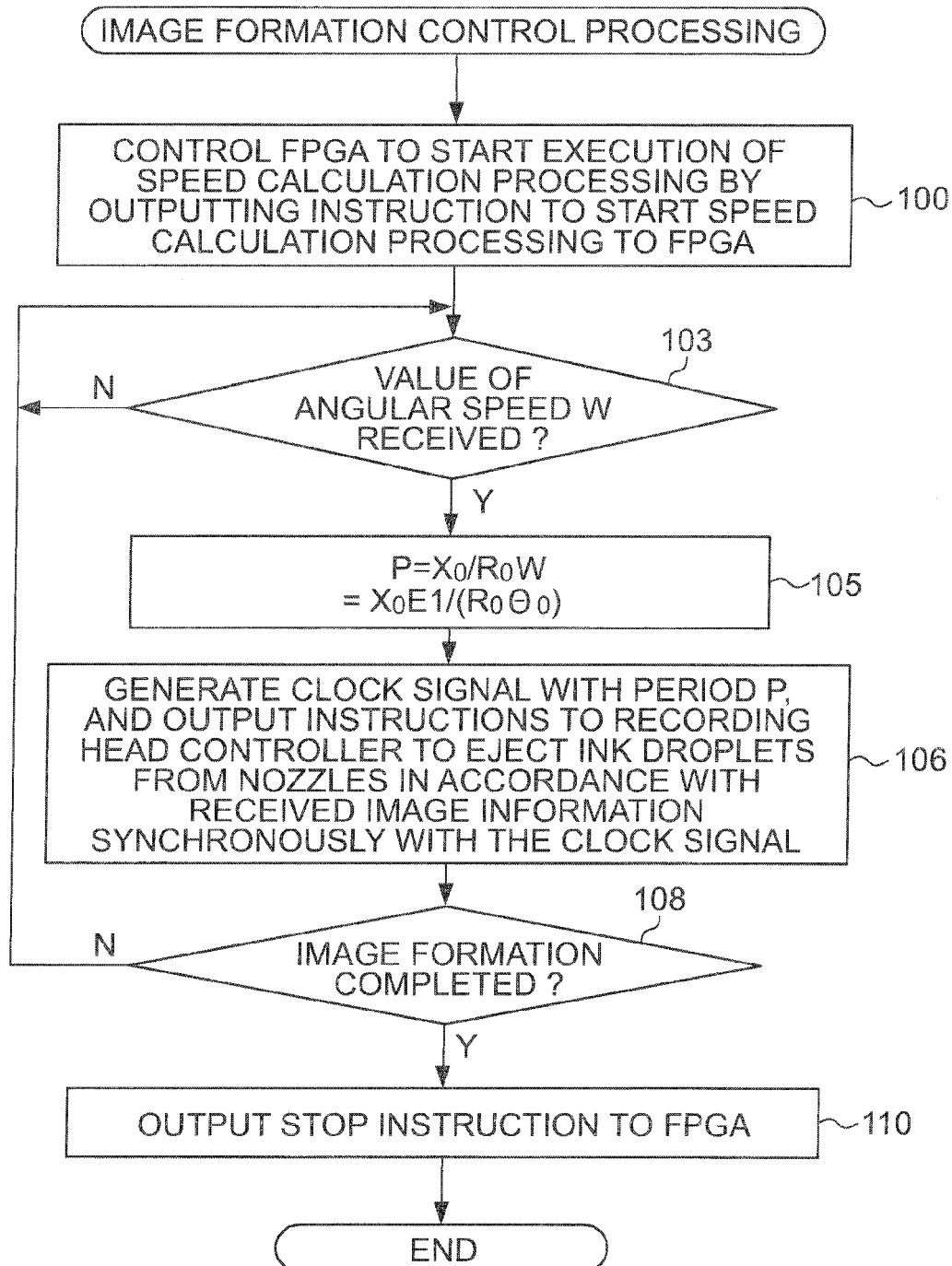


FIG.14

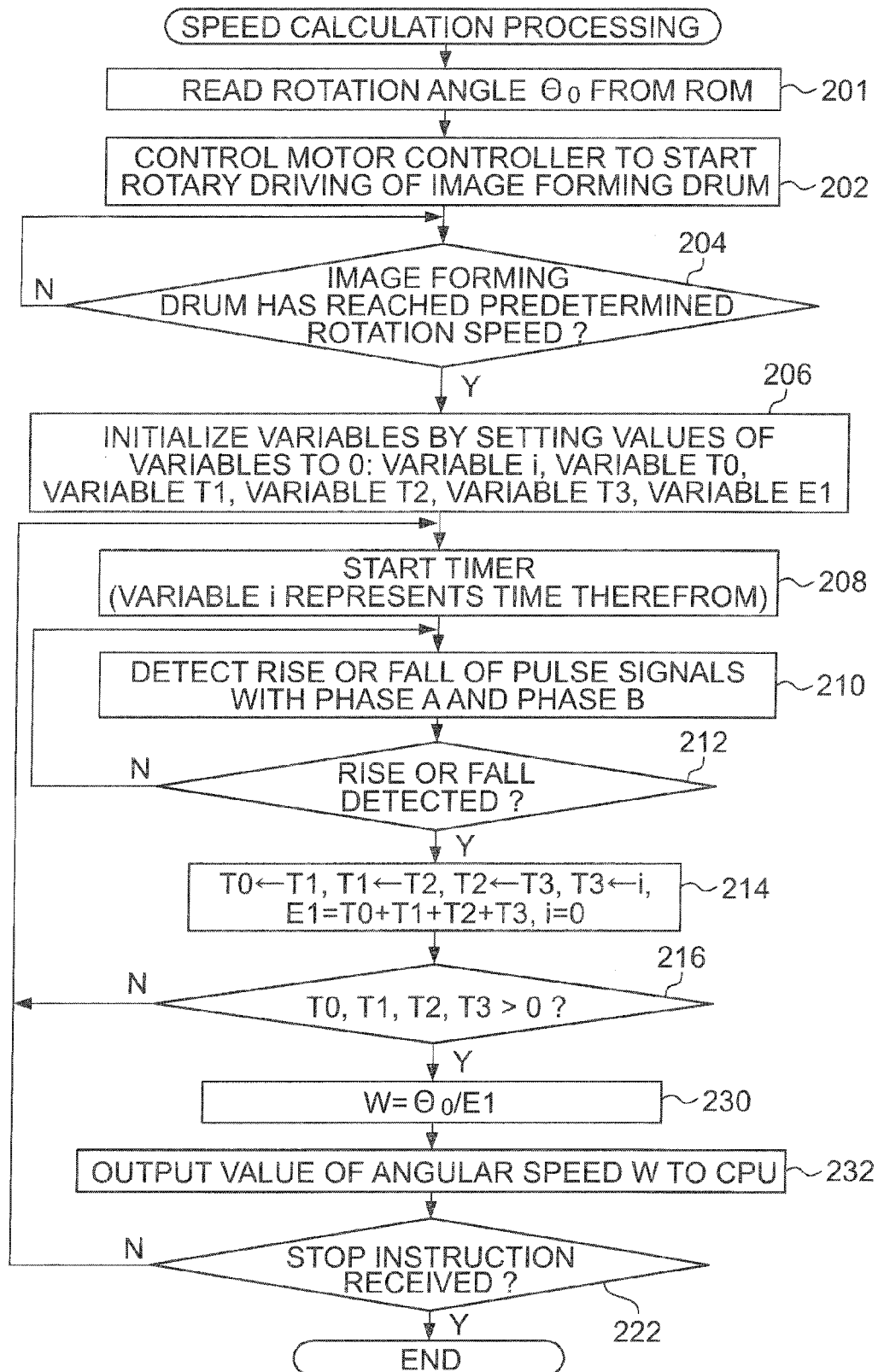


FIG.15

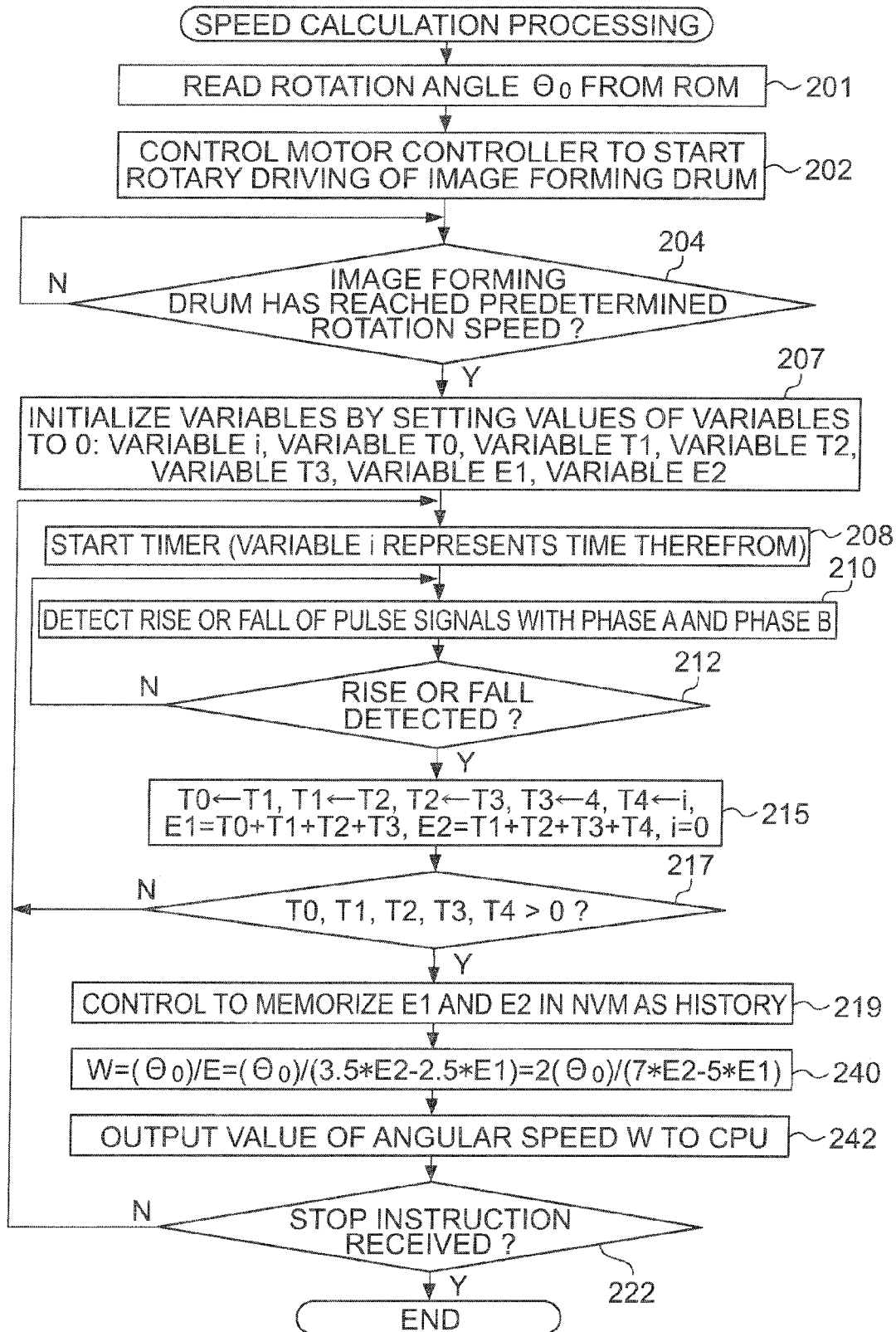


FIG.16

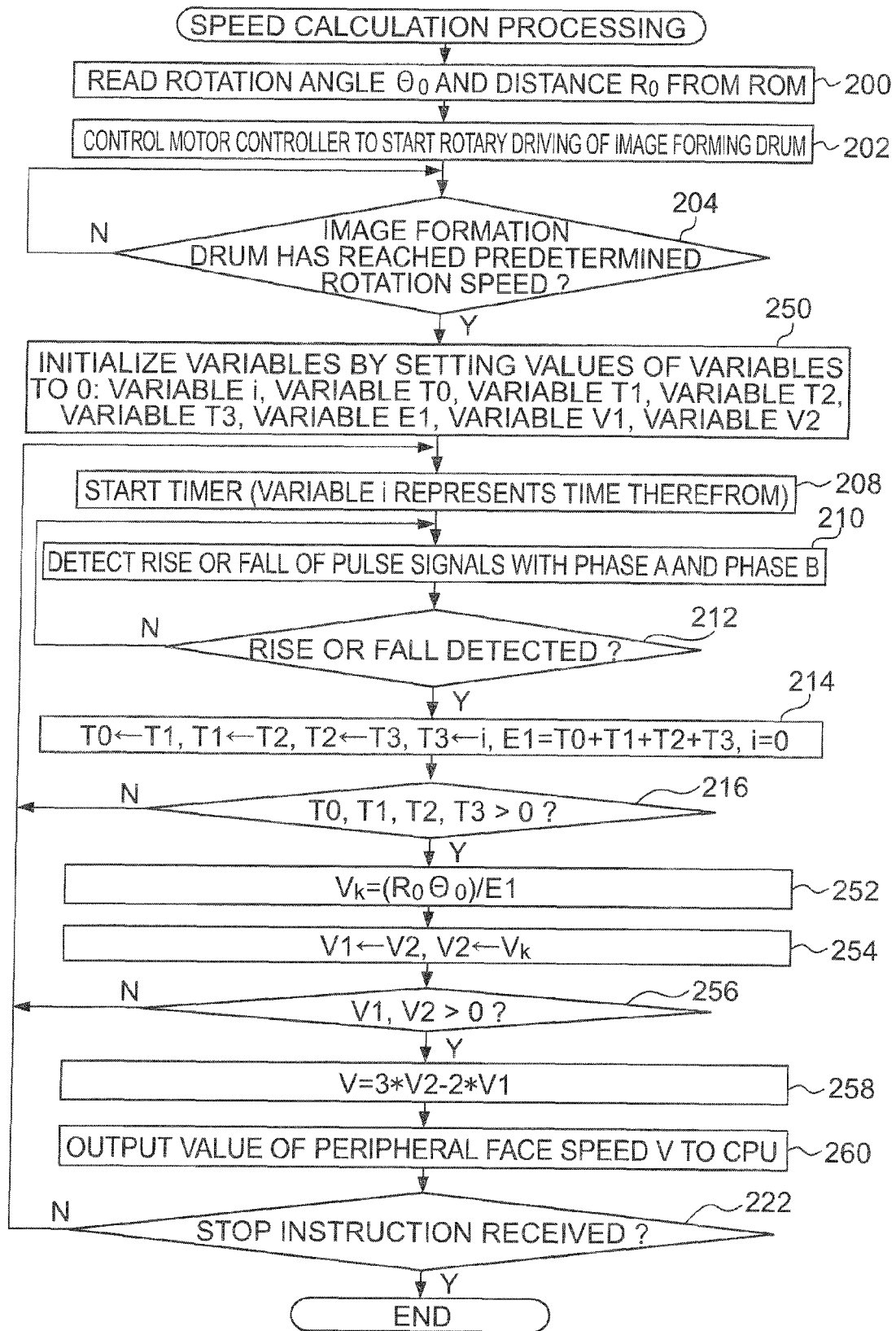
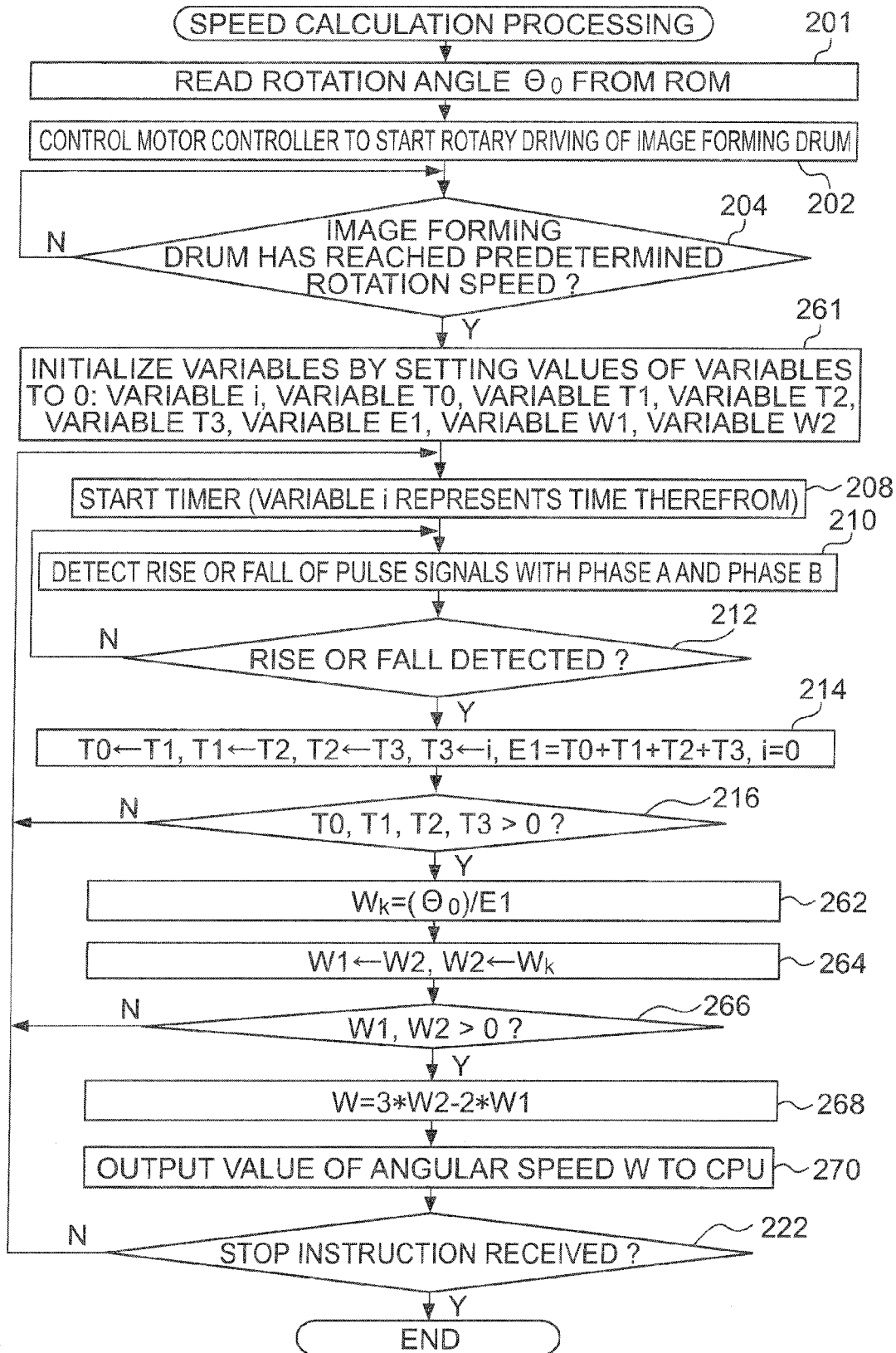


FIG.17



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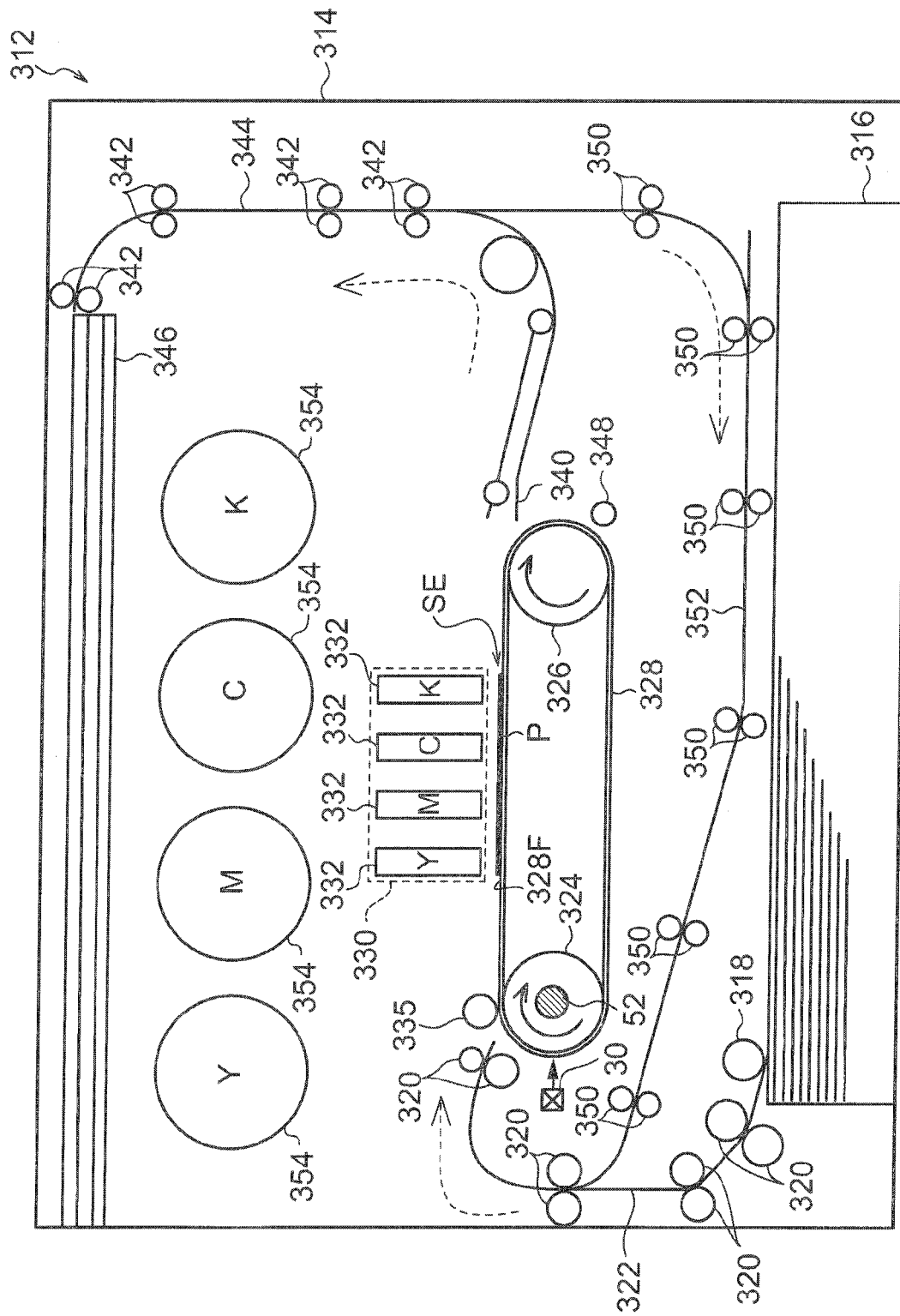


FIG.19

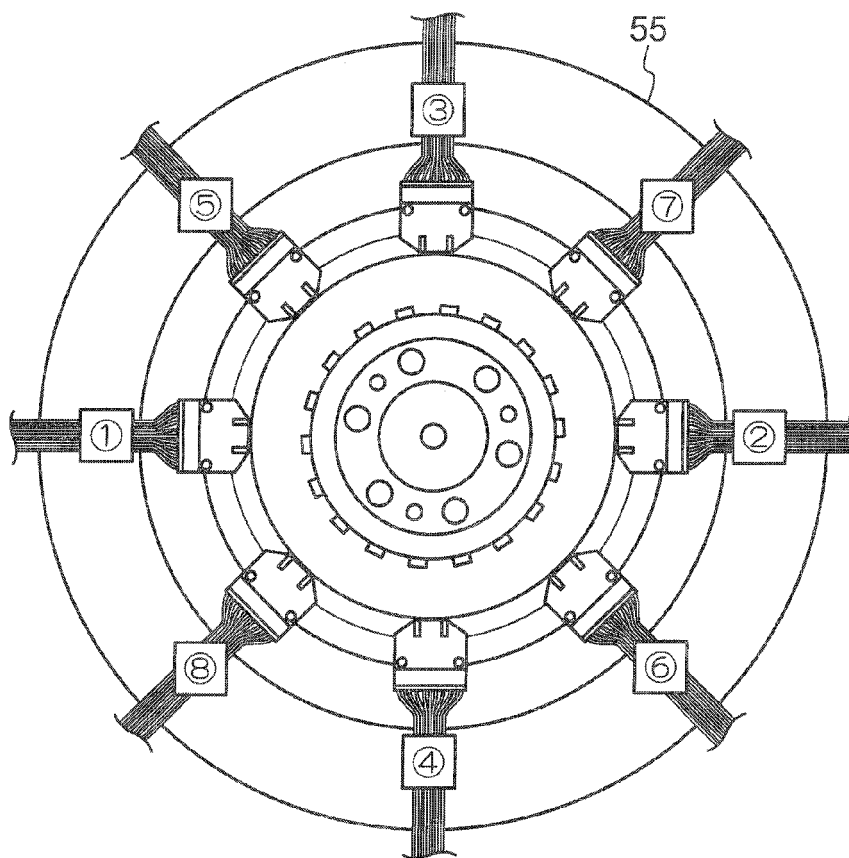


FIG.20

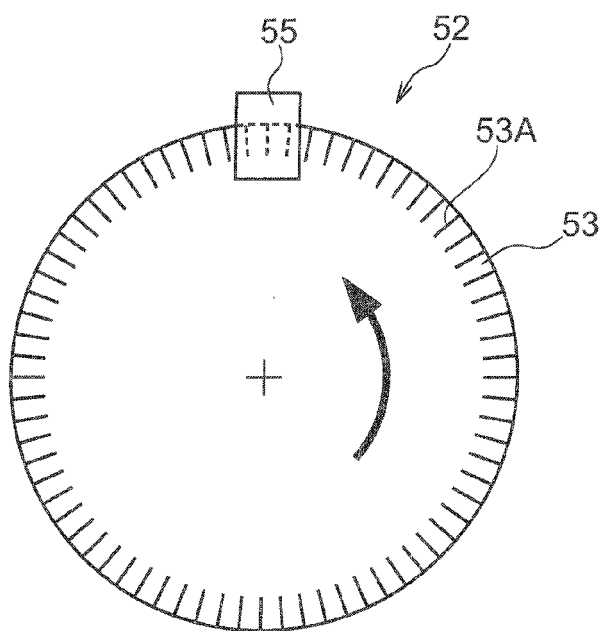


FIG.21

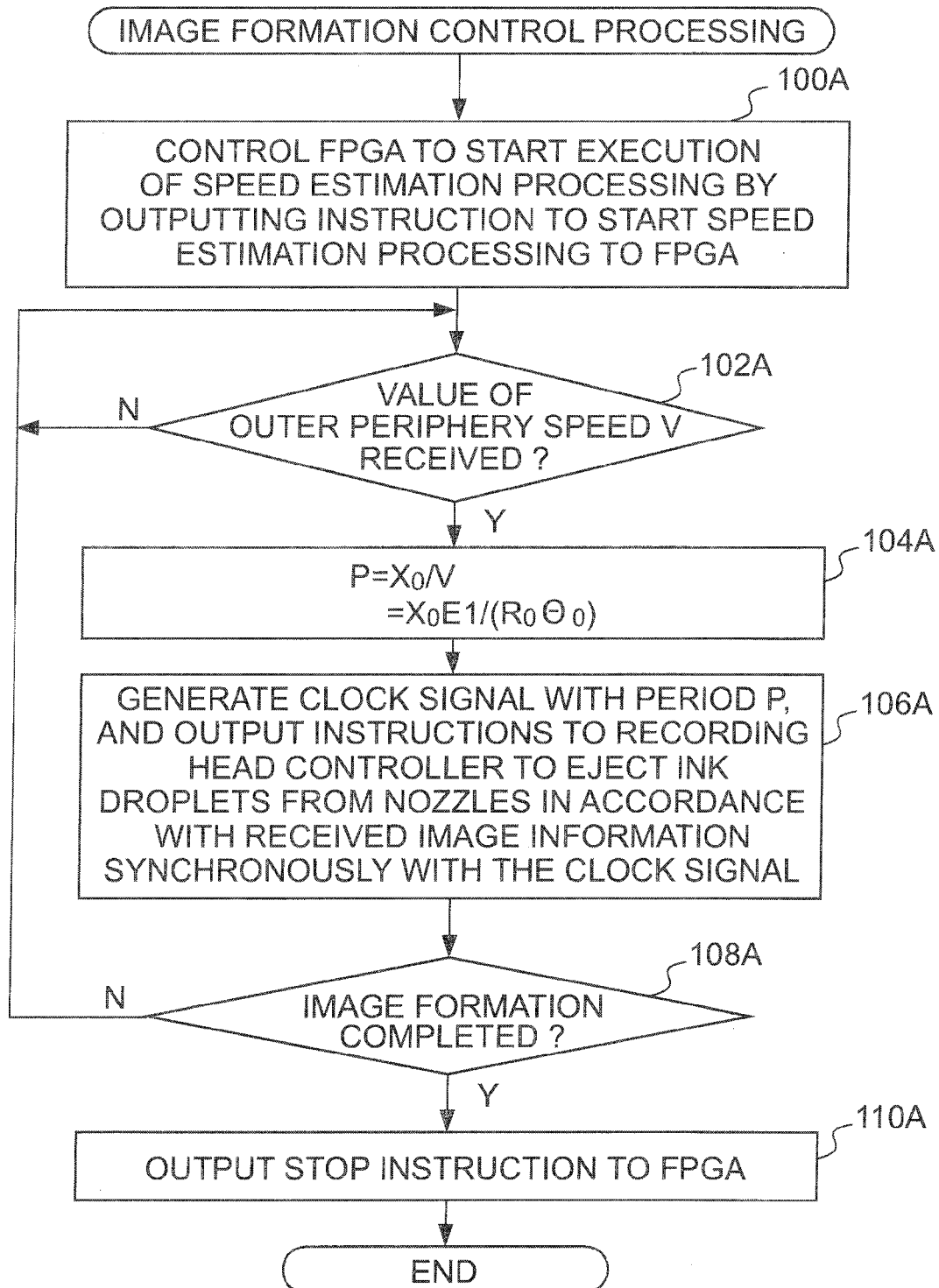


FIG.22

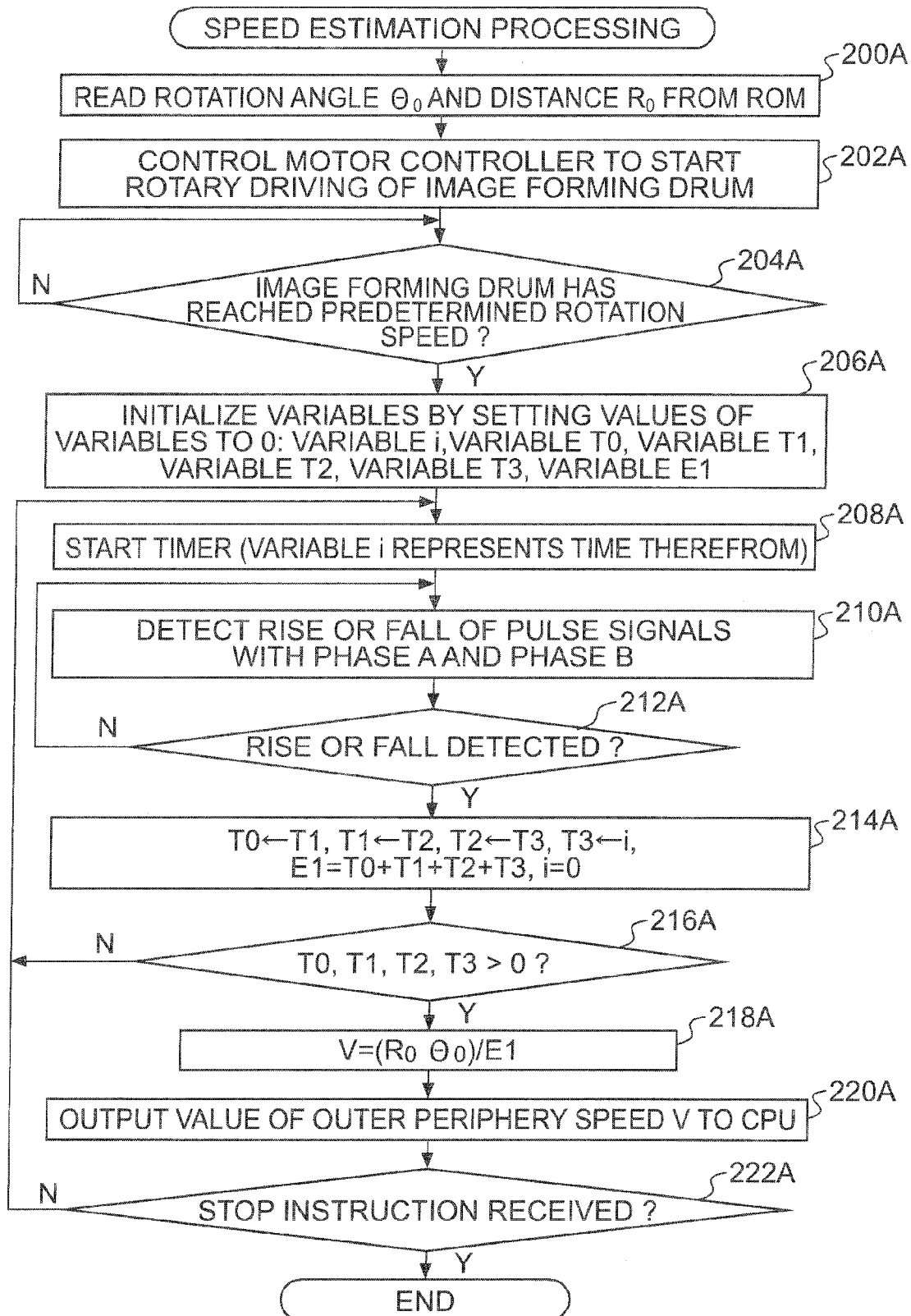


FIG.23

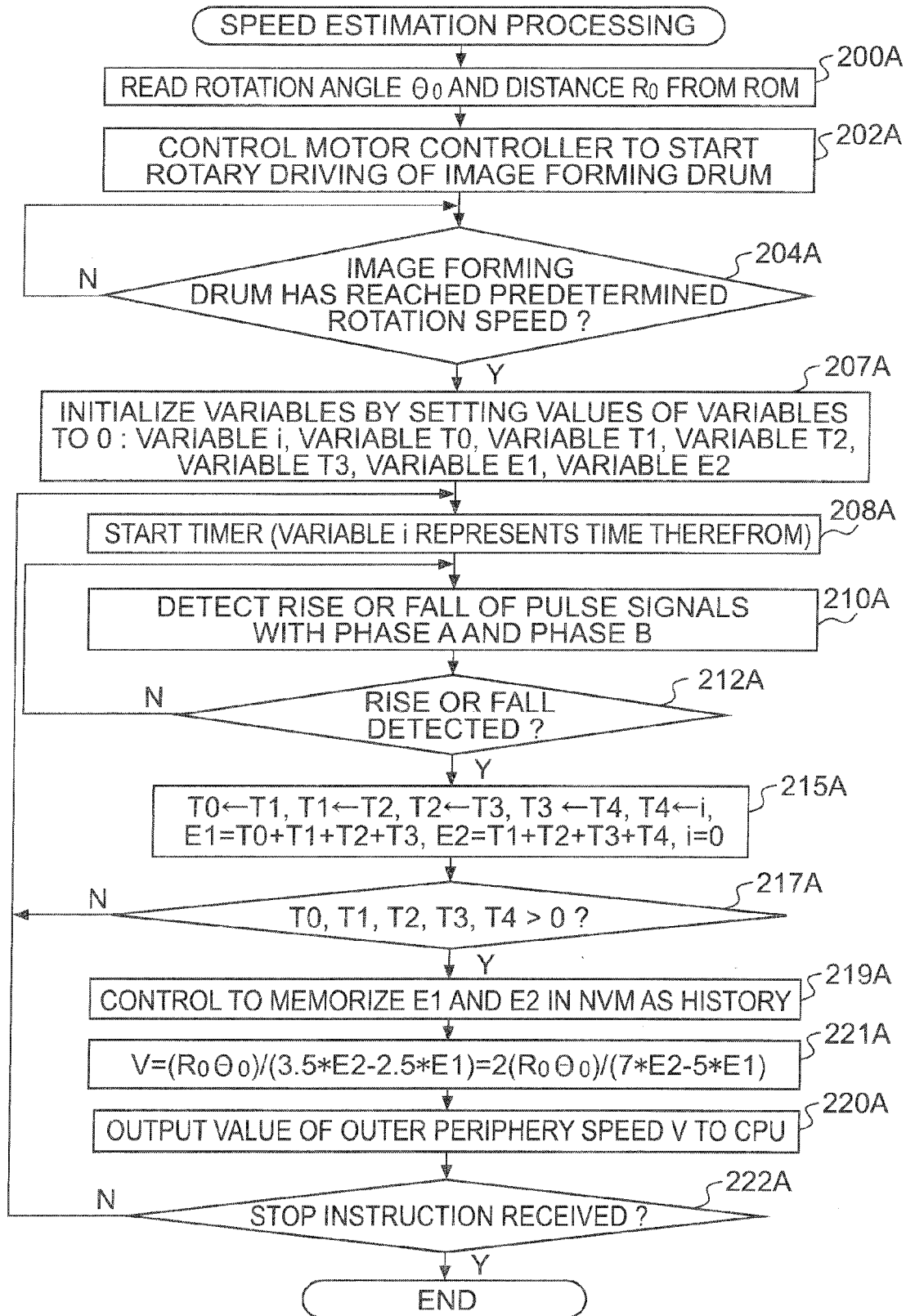


FIG.24

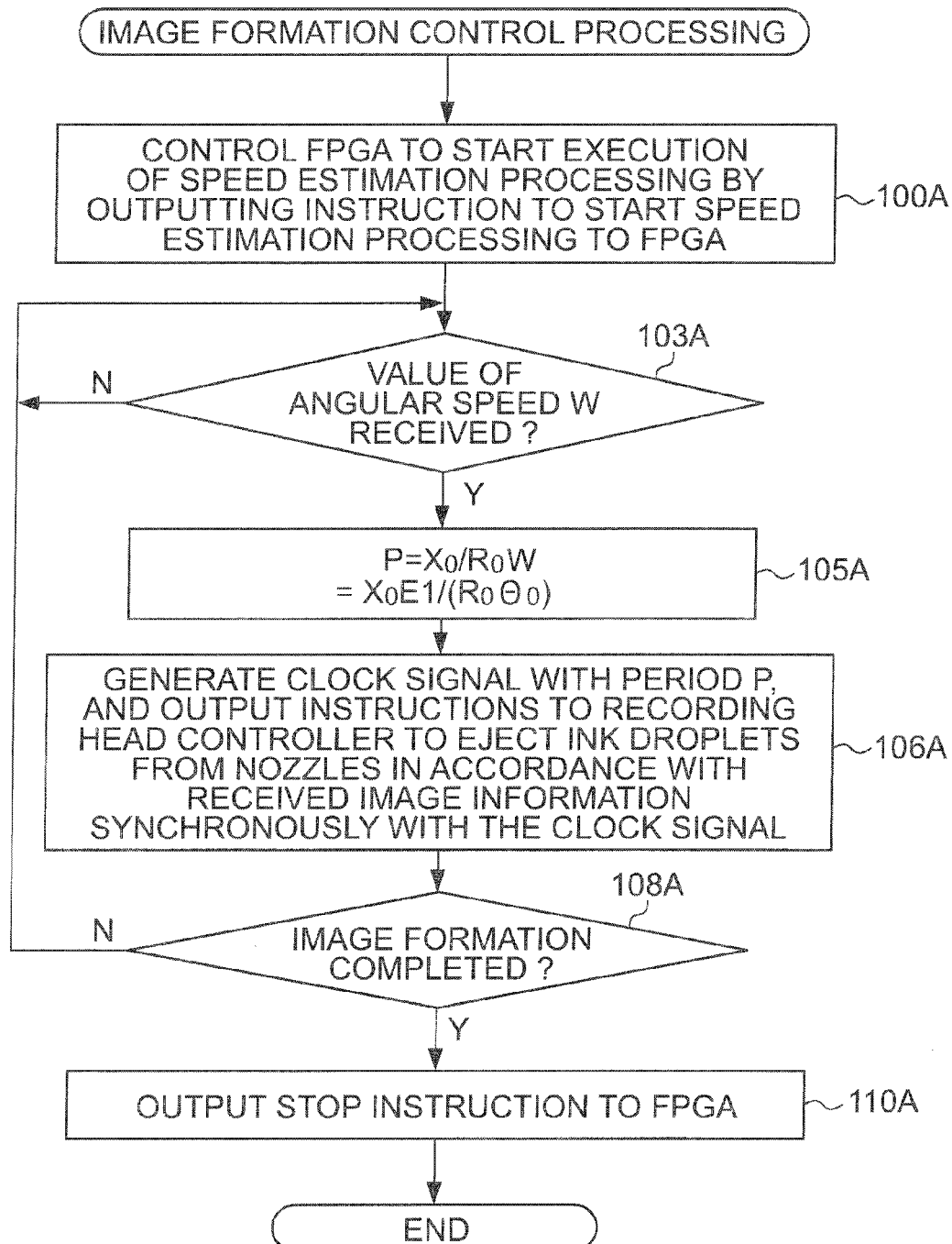


FIG.25

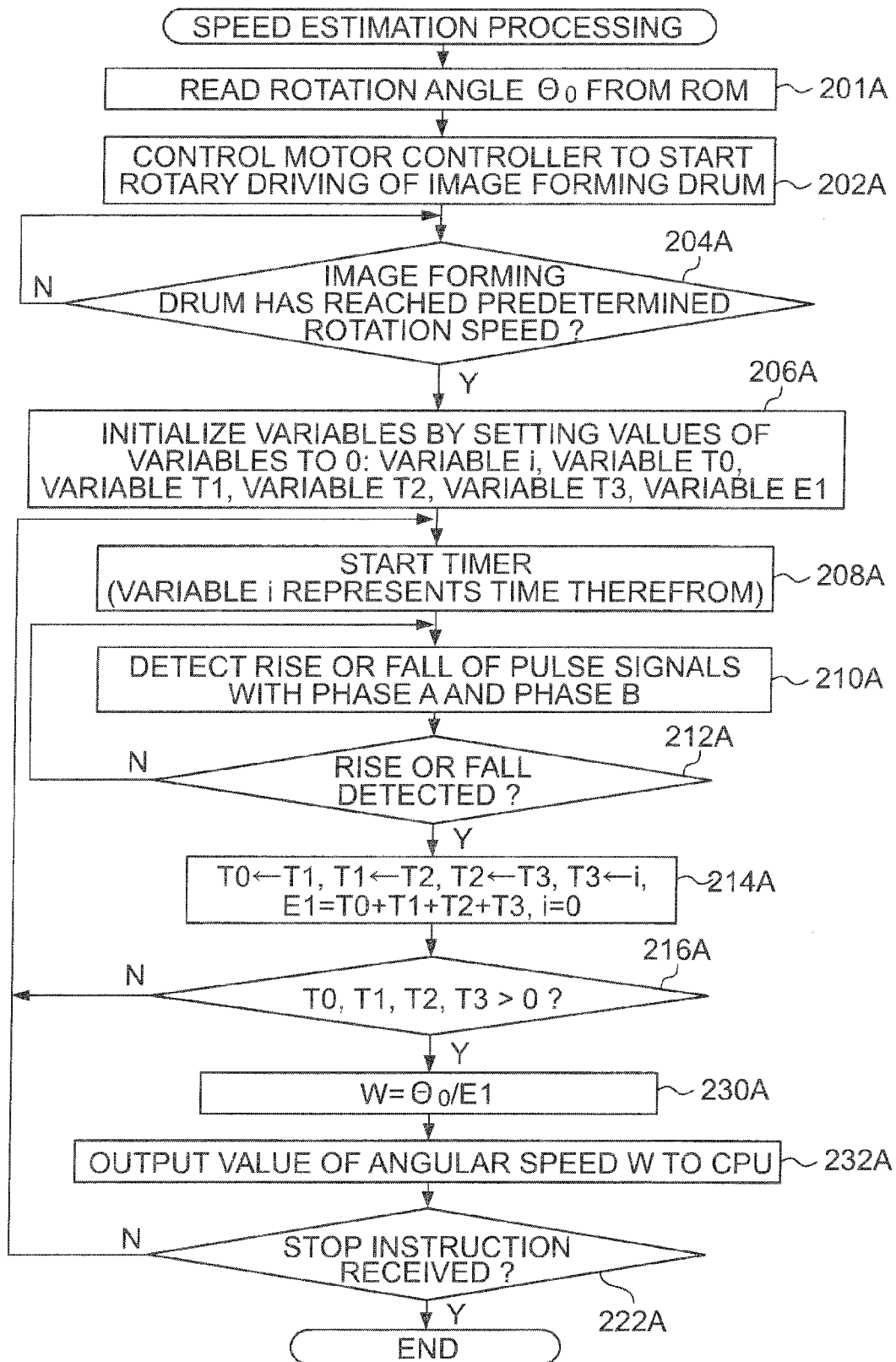


FIG.26

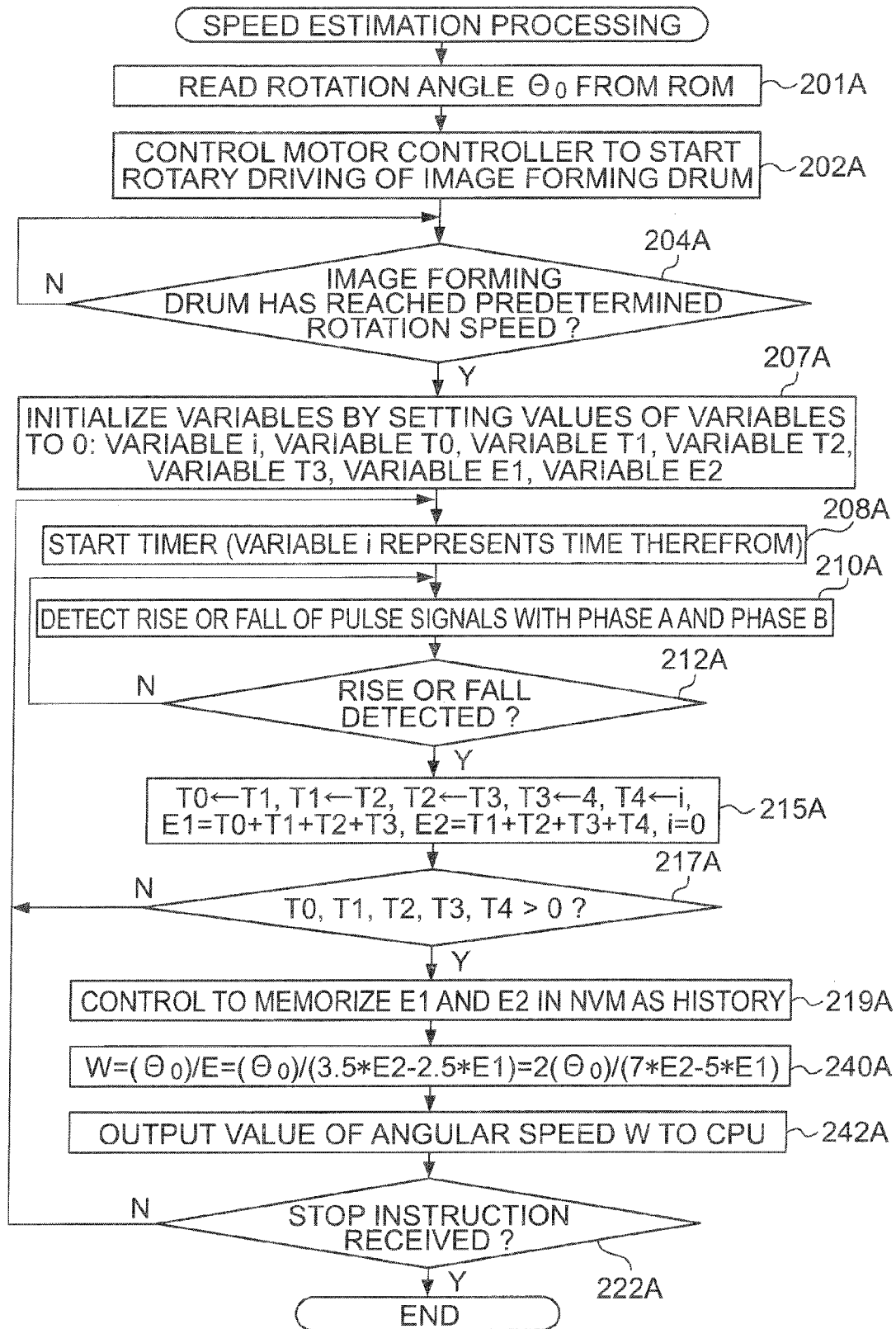


FIG.27

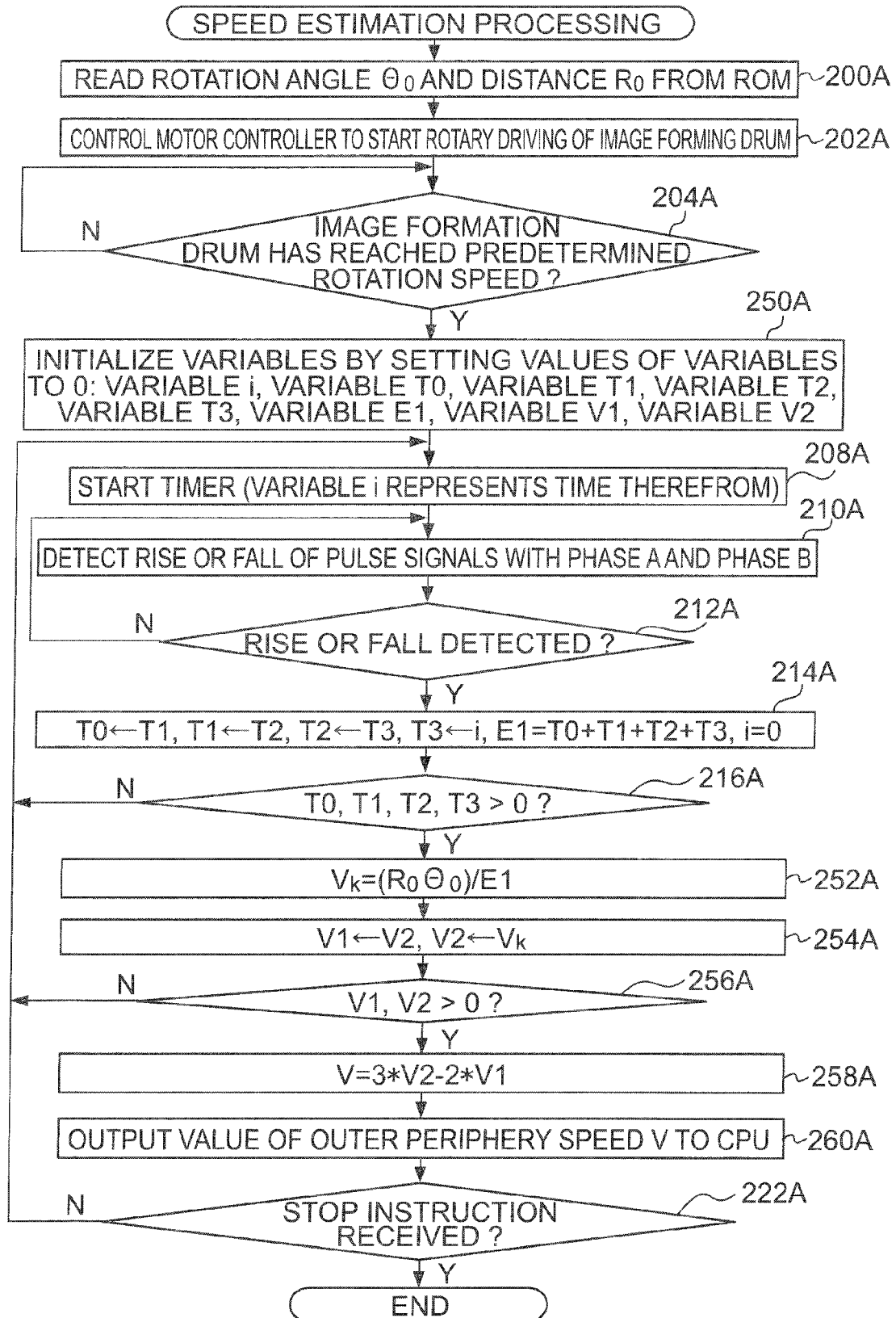
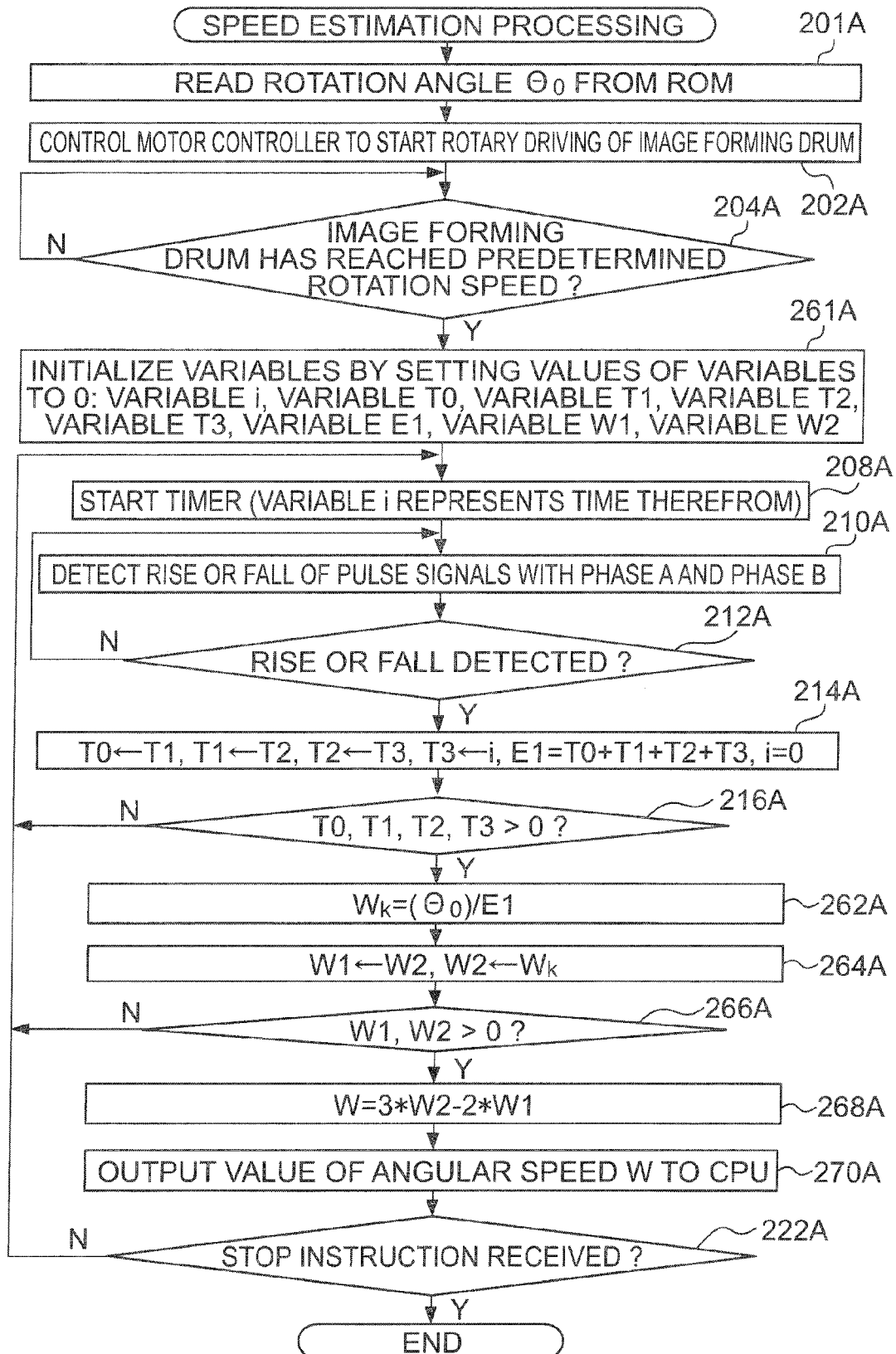


FIG.28



REFERENCES CITED IN THE DESCRIPTION

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