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(54) DOCUMENT IMAGE READING DEVICE

(76) Inventors: **Takao Horiuchi**, Nara-shi (JP); **Shigeru Watase**, Gojo-shi (JP); **Jun Morimoto**, Yamatokoriyama-shi (JP)

Correspondence Address:
DIKE, BRONSTEIN, ROBERTS AND CUSHMAN,
INTELLECTUAL PROPERTY PRACTICE GROUP
EDWARDS & ANGELL, LLP.
P.O. BOX 9169
BOSTON, MA 02209 (US)

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(30) **Foreign Application Priority Data**

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Publication Classification

(51) **Int. Cl.**[7] **H04N 1/04**

(52) **U.S. Cl.** **358/474**

(57) **ABSTRACT**

The invention is directed to provide a document-image reading device that can analyze a speed fluctuation state of a scanner when scanning an image in the feed direction by separately extracting speed fluctuation components by reading a change in density of reference scale lines and, on the basis of the analysis result, prevents the occurrence of an image blur that may be resulting from unstable factors of a driving mechanism. The document-image reading device for reading a document image data at a specified time-interval given by the reference clock signal, which comprises document-image reading means for reading a document image by moving the means or the document in the feed direction and is featured in that the document-image reading means is further provided with chart reading means for reading a reference chart portion having alternations of a high-density division and a low-density division arranged one after another at a distance-interval equal to a least pitch readable by the document-image reading means along the feed direction and processing means for processing image data read from the reference chart portion integration by using a comb-type filter and by integration.

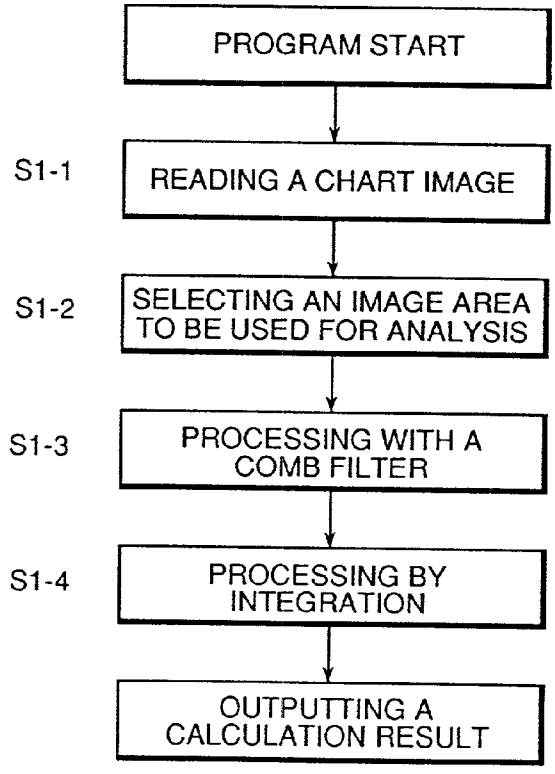


FIG.1
(PRIOR ART)

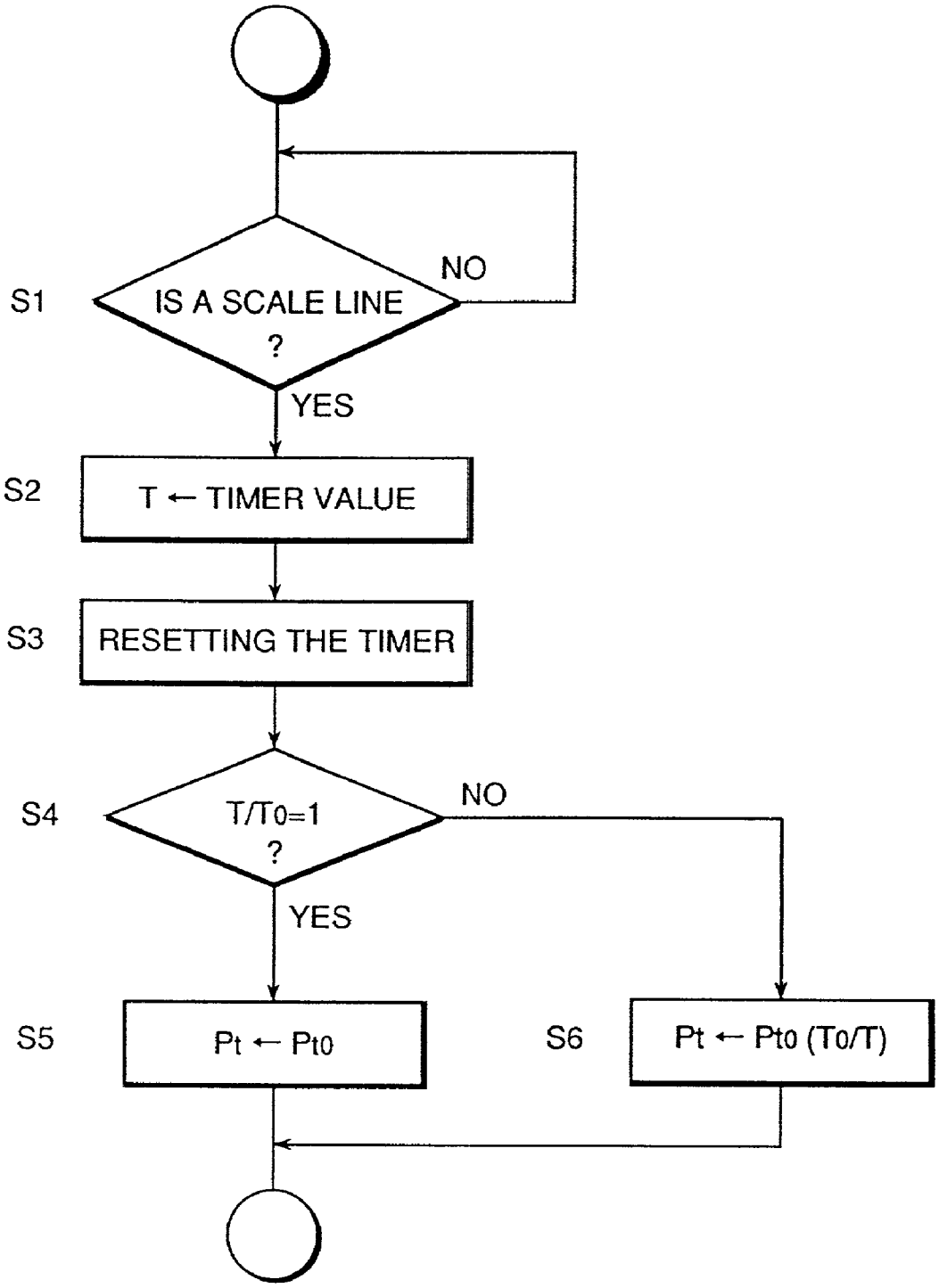


FIG.2

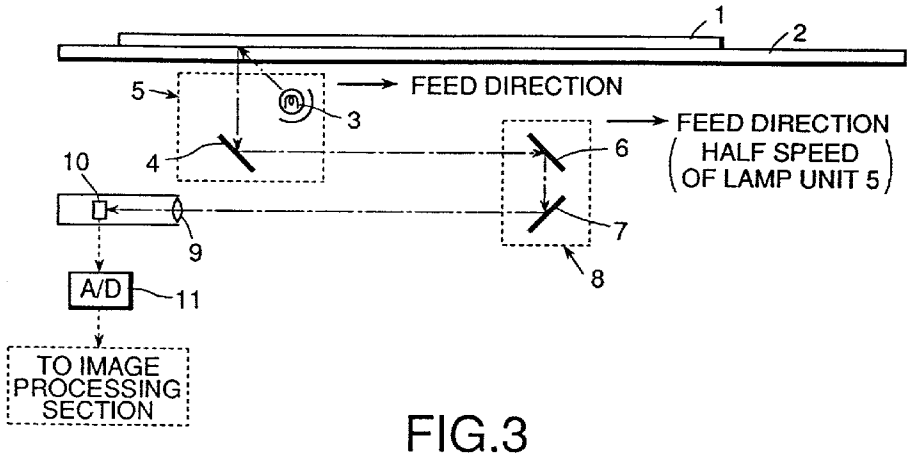


FIG.3

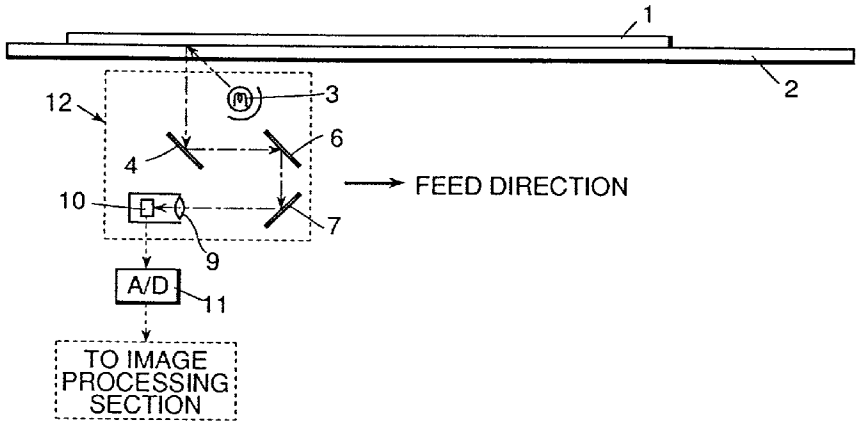


FIG.4

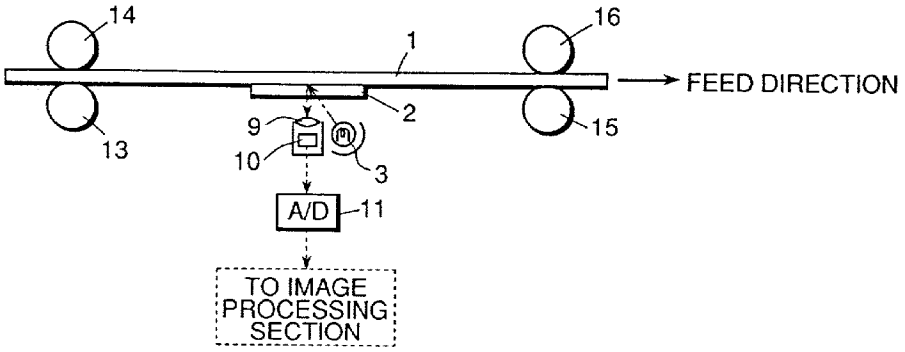


FIG.5

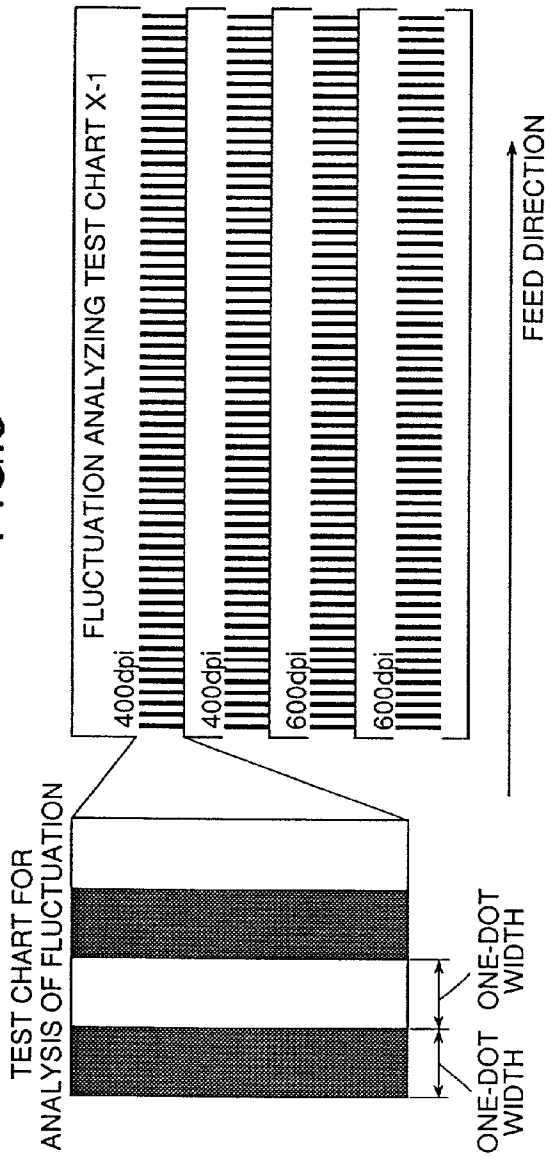

FLUCTUATION ANALYZING TEST CHART X-1
400dpi
400dpi
600dpi
600dpi
FEED DIRECTION
TEST CHART FOR ANALYSIS OF FLUCTUATION
ONE-DOT WIDTH
ONE-DOT WIDTH

FIG.6

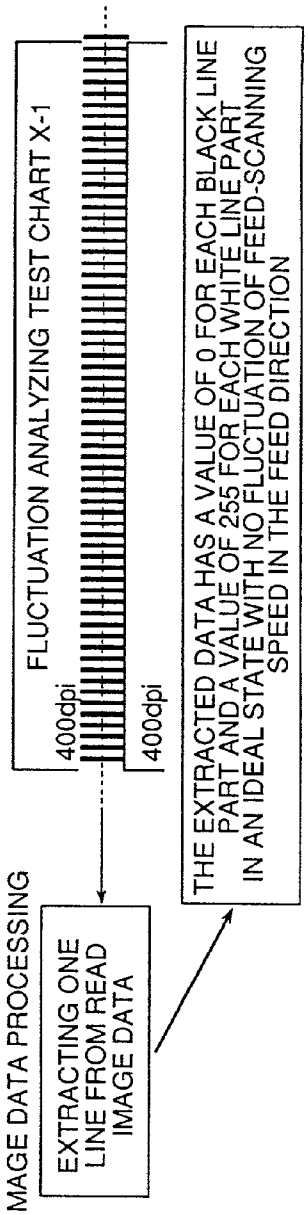

FLUCTUATION ANALYZING TEST CHART X-1
400dpi
400dpi
IMAGE DATA PROCESSING
EXTRACTING ONE LINE FROM READ IMAGE DATA
THE EXTRACTED DATA HAS A VALUE OF 0 FOR EACH BLACK LINE PART AND A VALUE OF 255 FOR EACH WHITE LINE PART IN AN IDEAL STATE WITH NO FLUCTUATION OF FEED-SCANNING SPEED IN THE FEED DIRECTION

FIG.7

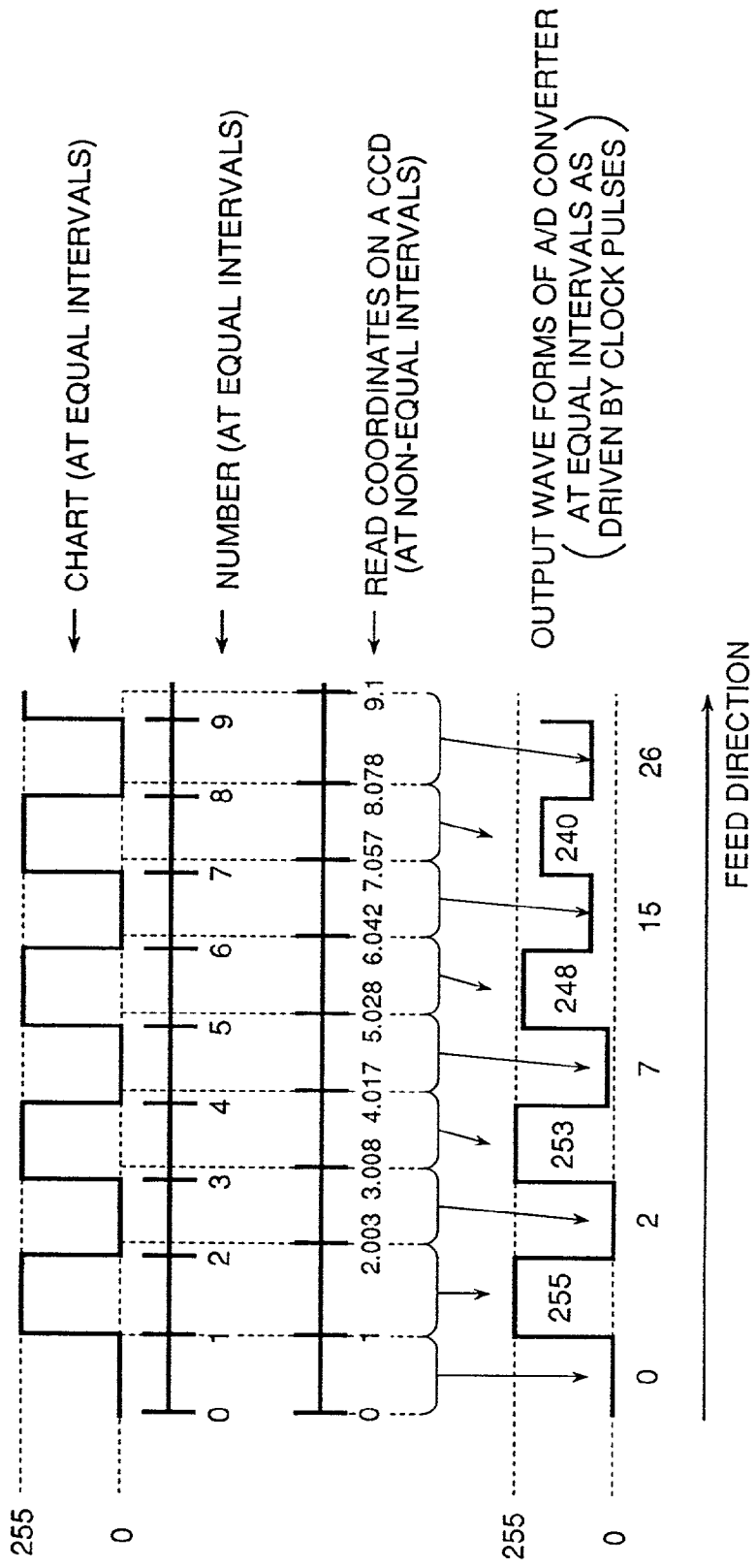


CHART (AT EQUAL INTERVALS)
NUMBER (AT EQUAL INTERVALS)
READ COORDINATES ON A CCD (AT NON-EQUAL INTERVALS)
OUTPUT WAVE FORMS OF A/D CONVERTER (AT EQUAL INTERVALS AS DRIVEN BY CLOCK PULSES)
FEED DIRECTION
255
0
0 1 2 3 4 5 6 7 8 9
0 1 2.003 3.008 4.017 5.028 6.042 7.057 8.078 9.1
255 253 248 240
0 2 7 15 26

FIG.8

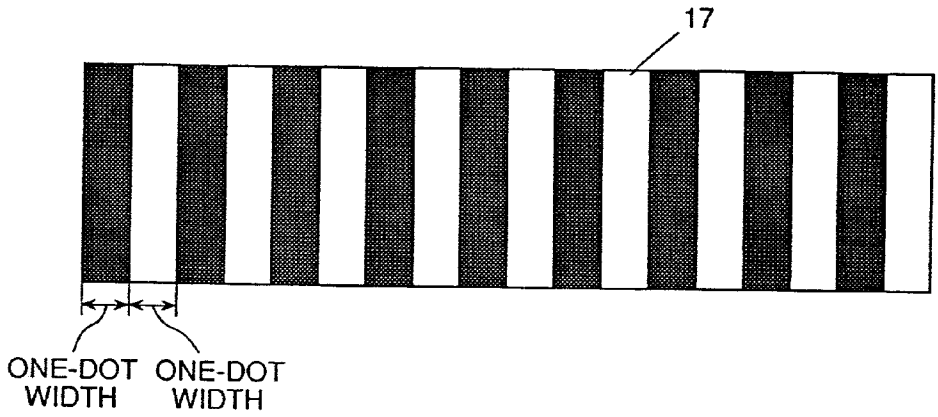

17
ONE-DOT WIDTH
ONE-DOT WIDTH

FIG.9

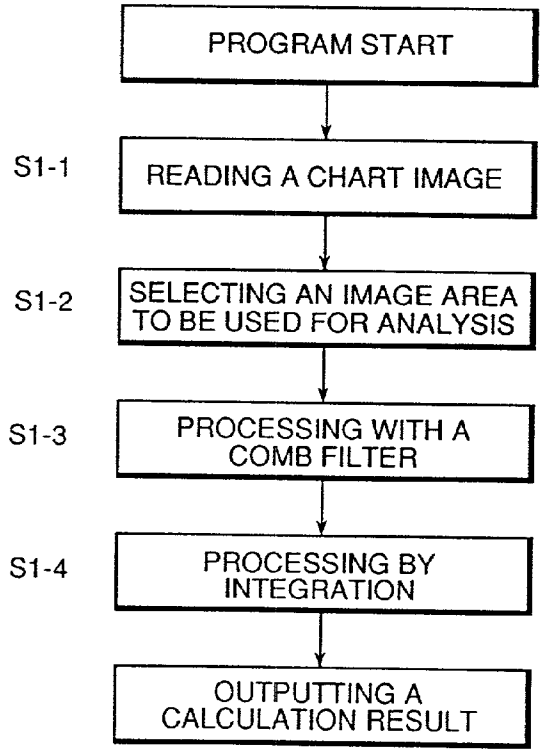

PROGRAM START
S1-1
READING A CHART IMAGE
S1-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
S1-3
PROCESSING WITH A COMB FILTER
S1-4
PROCESSING BY INTEGRATION
OUTPUTTING A CALCULATION RESULT

FIG.10

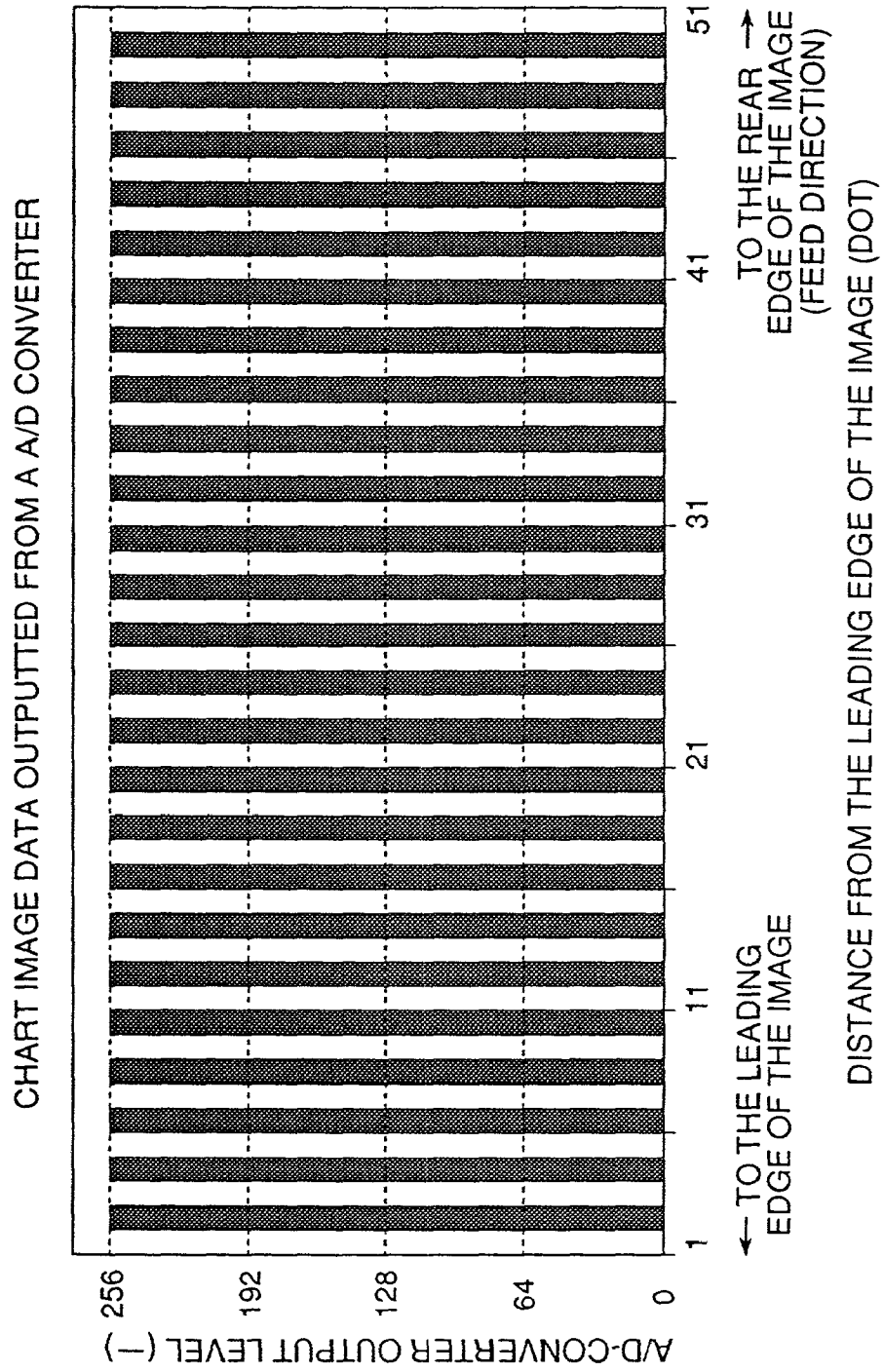


CHART IMAGE DATA OUTPUTTED FROM A A/D CONVERTER
A/D-CONVERTER OUTPUT LEVEL (—)
256
192
128
64
0
1
11
21
31
41
51
← TO THE LEADING EDGE OF THE IMAGE
TO THE REAR → EDGE OF THE IMAGE (FEED DIRECTION)
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.11

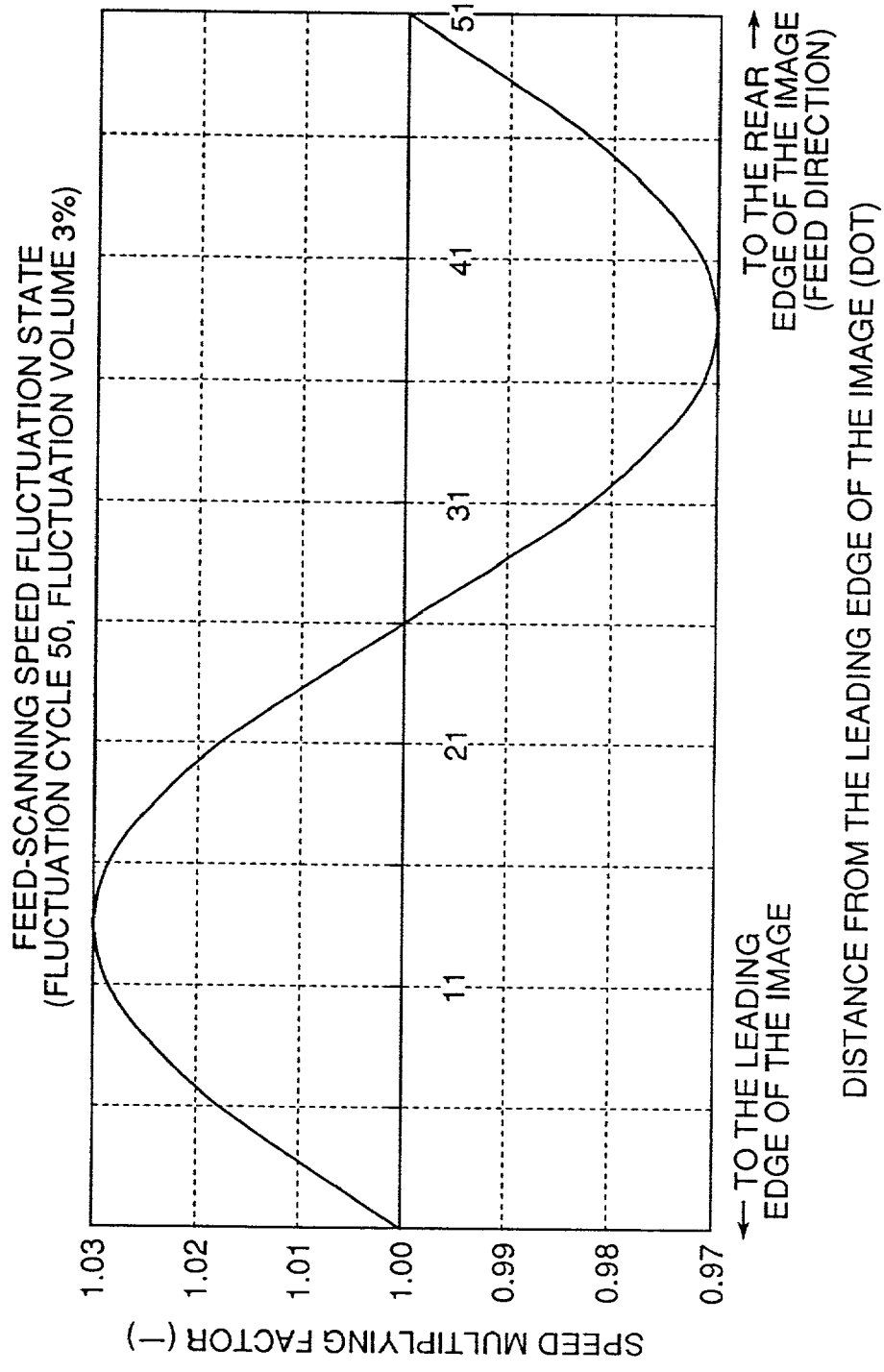

FEED-SCANNING SPEED FLUCTUATION STATE
(FLUCTUATION CYCLE 50, FLUCTUATION VOLUME 3%)
SPEED MULTIPLYING FACTOR (—)
1.03
1.02
1.01
1.00
0.99
0.98
0.97
11
21
31
41
51
← TO THE LEADING EDGE OF THE IMAGE
TO THE REAR → EDGE OF THE IMAGE (FEED DIRECTION)
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.12

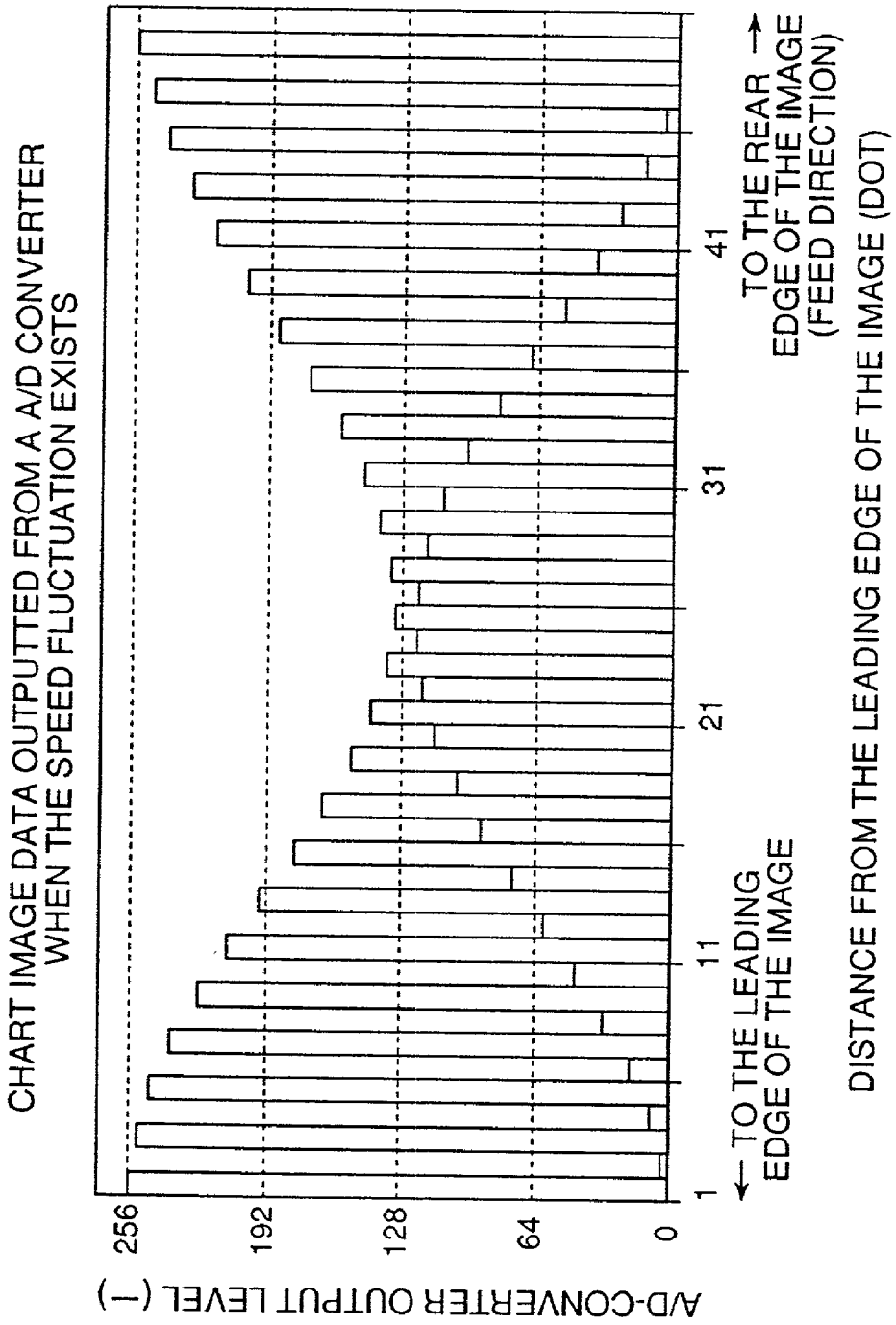


CHART IMAGE DATA OUTPUTTED FROM A A/D CONVERTER WHEN THE SPEED FLUCTUATION EXISTS
A/D-CONVERTER OUTPUT LEVEL (—)
256
192
128
64
0
1
11
21
31
41
← TO THE LEADING EDGE OF THE IMAGE
TO THE REAR → EDGE OF THE IMAGE (FEED DIRECTION)
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.13

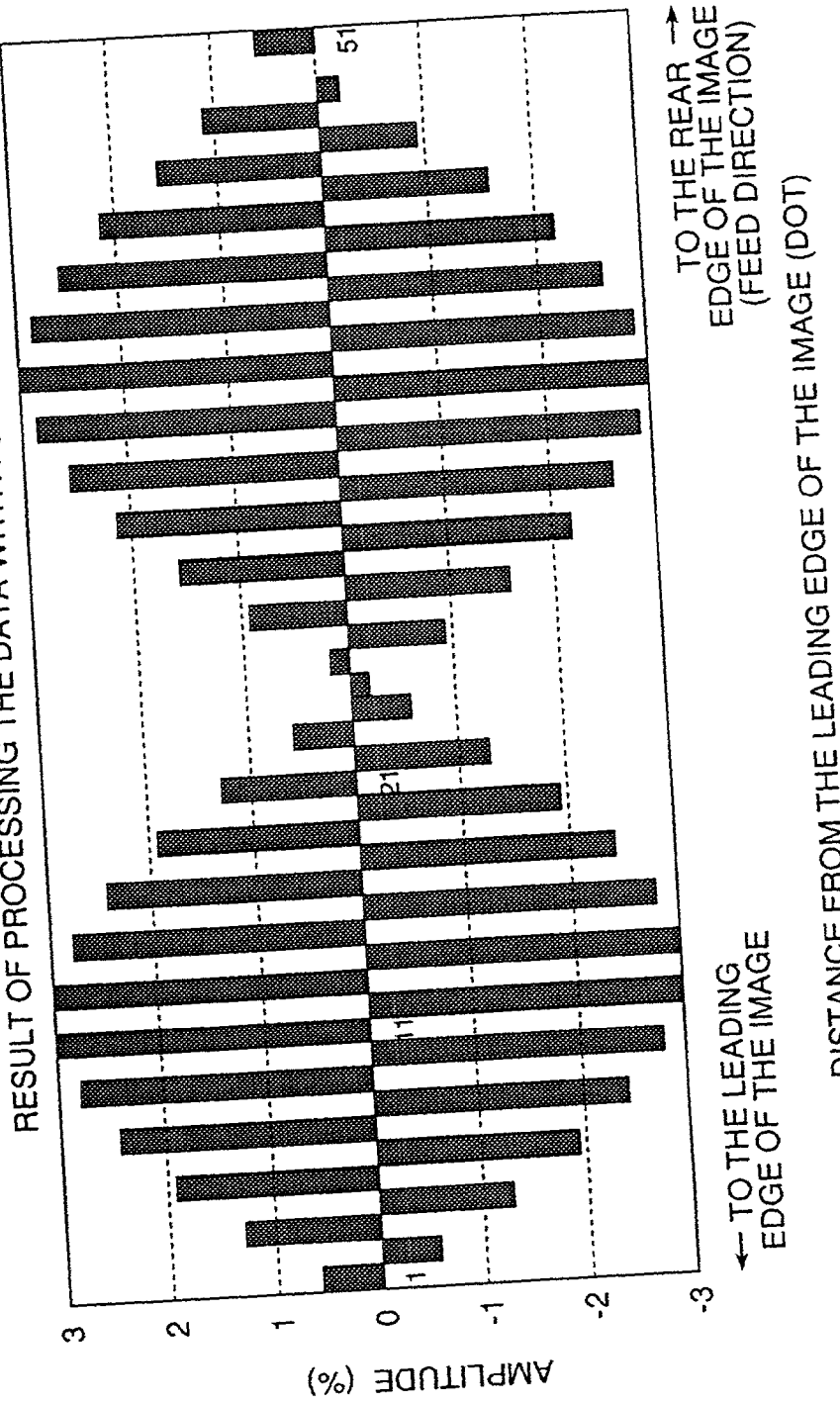

RESULT OF PROCESSING THE DATA WITH A COMB FILTER
AMPLITUDE (%)
3
2
1
0
-1
-2
-3
51
P1
11
1
← TO THE LEADING EDGE OF THE IMAGE
TO THE REAR → EDGE OF THE IMAGE (FEED DIRECTION)
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.14

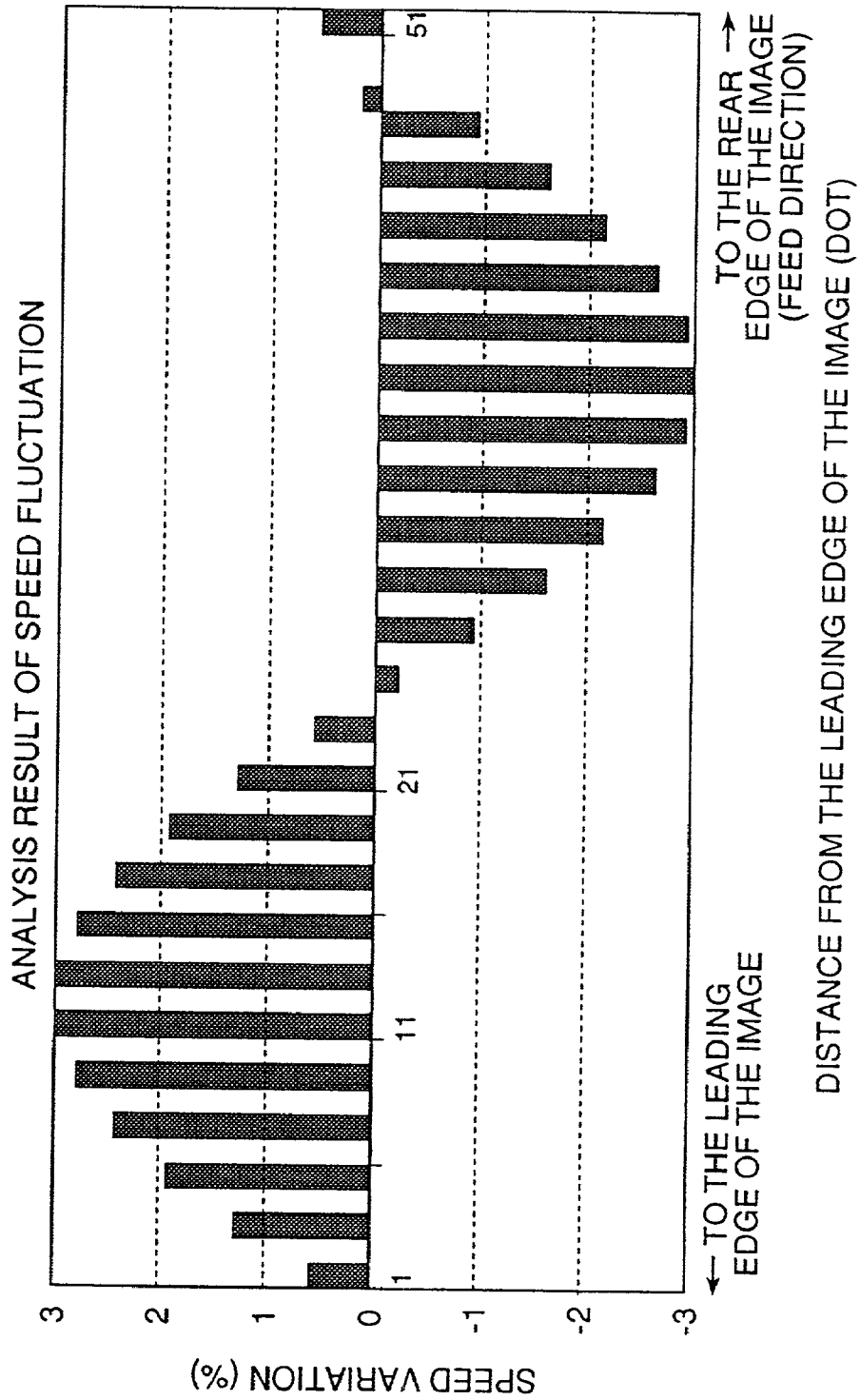

ANALYSIS RESULT OF SPEED FLUCTUATION
SPEED VARIATION (%)
3
2
1
0
-1
-2
-3
1
11
21
51
← TO THE LEADING EDGE OF THE IMAGE
TO THE REAR → EDGE OF THE IMAGE (FEED DIRECTION)
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.15

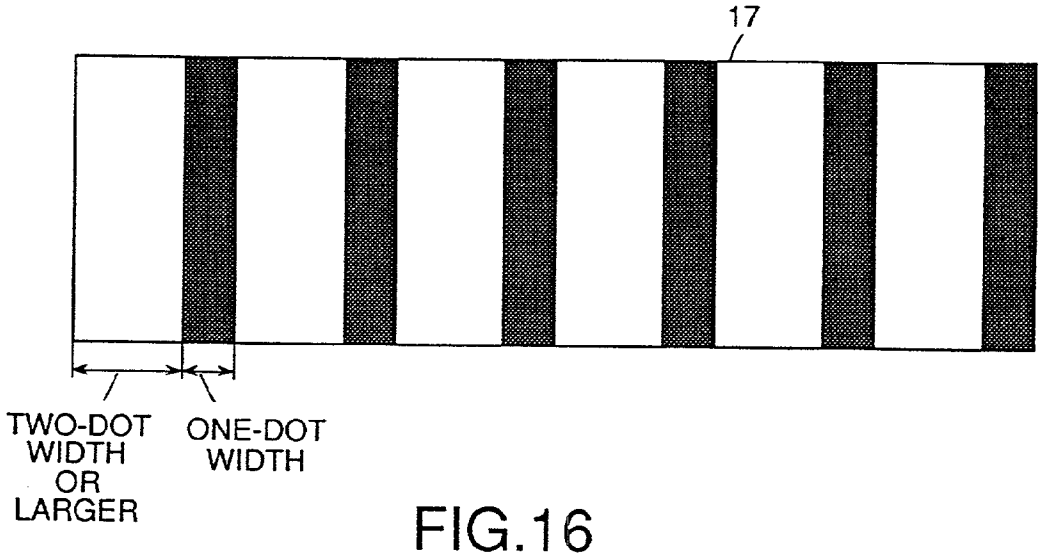

17
TWO-DOT WIDTH OR LARGER
ONE-DOT WIDTH

FIG.16

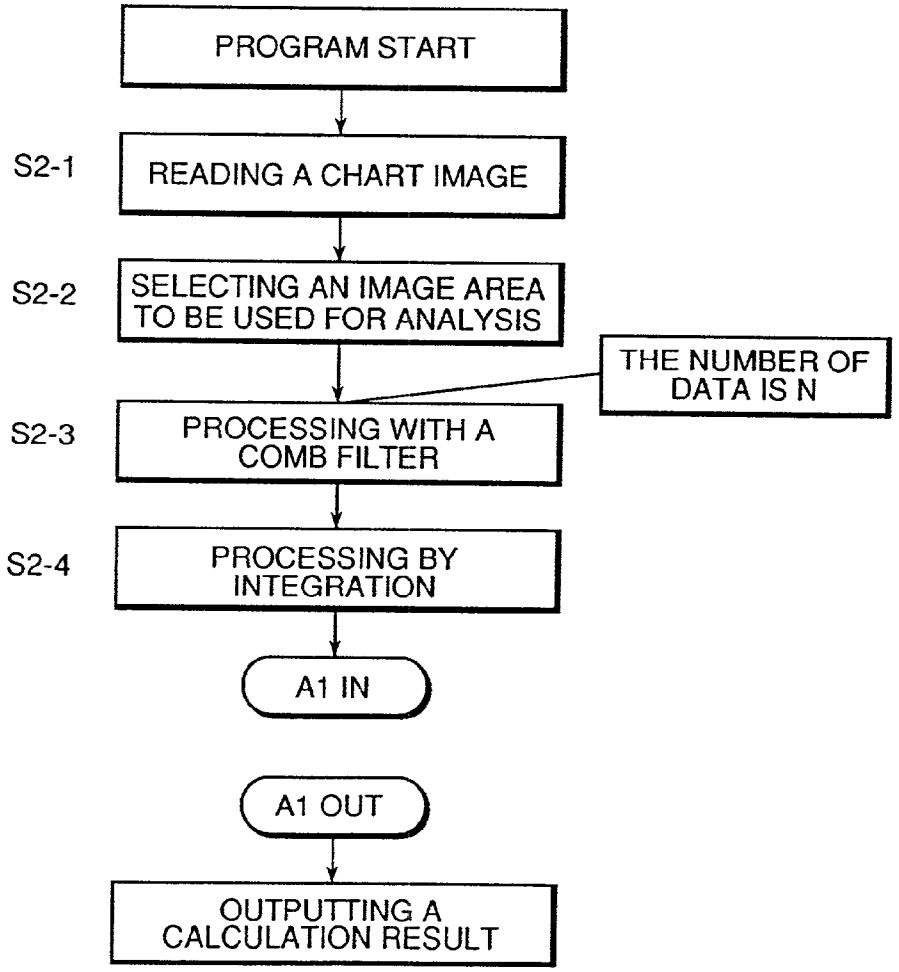

PROGRAM START
S2-1
READING A CHART IMAGE
S2-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
THE NUMBER OF DATA IS N
S2-3
PROCESSING WITH A COMB FILTER
S2-4
PROCESSING BY INTEGRATION
A1 IN
A1 OUT
OUTPUTTING A CALCULATION RESULT

FIG.17

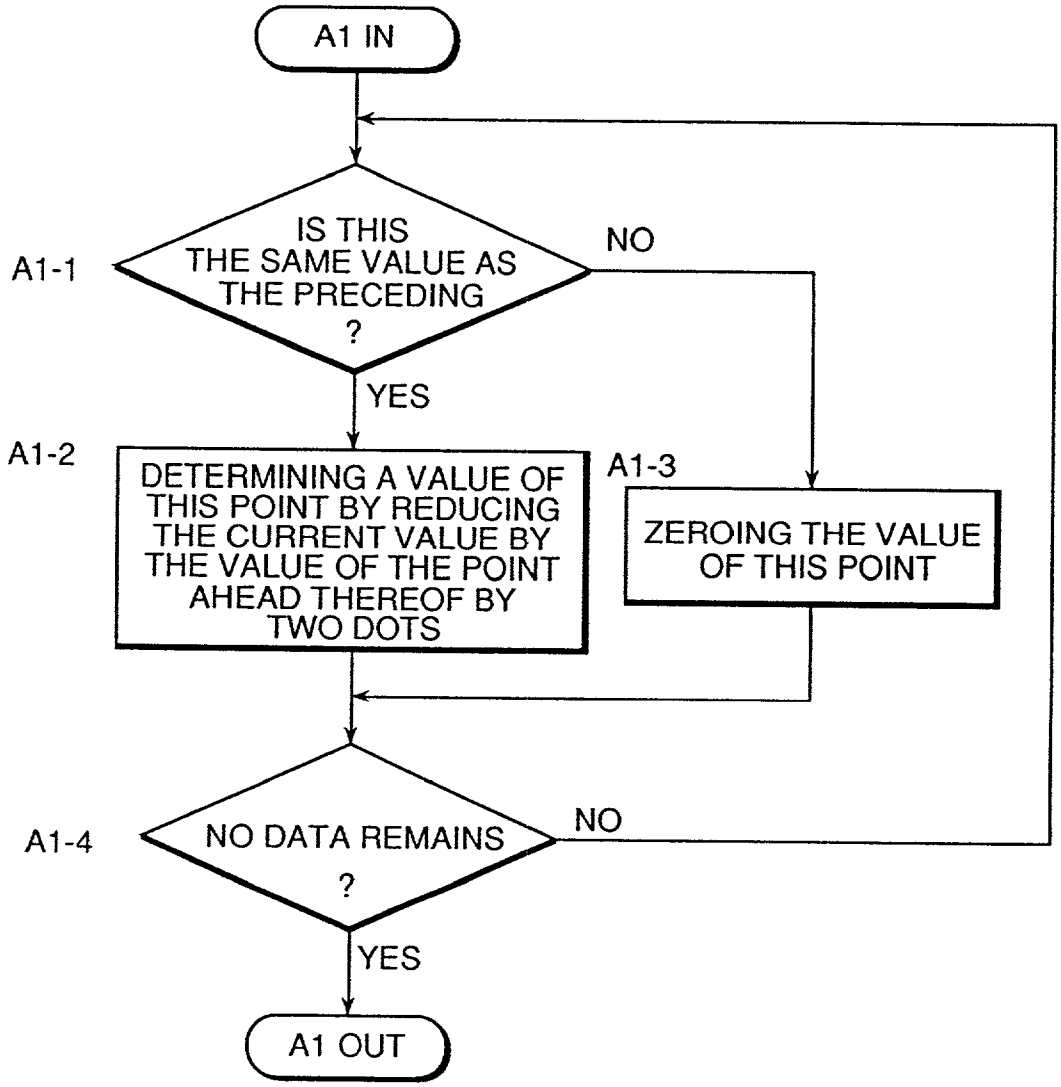

A1 IN
A1-1
IS THIS THE SAME VALUE AS THE PRECEDING ?
NO
YES
A1-2
DETERMINING A VALUE OF THIS POINT BY REDUCING THE CURRENT VALUE BY THE VALUE OF THE POINT AHEAD THEREOF BY TWO DOTS
A1-3
ZEROING THE VALUE OF THIS POINT
A1-4
NO DATA REMAINS ?
NO
YES
A1 OUT

FIG.18

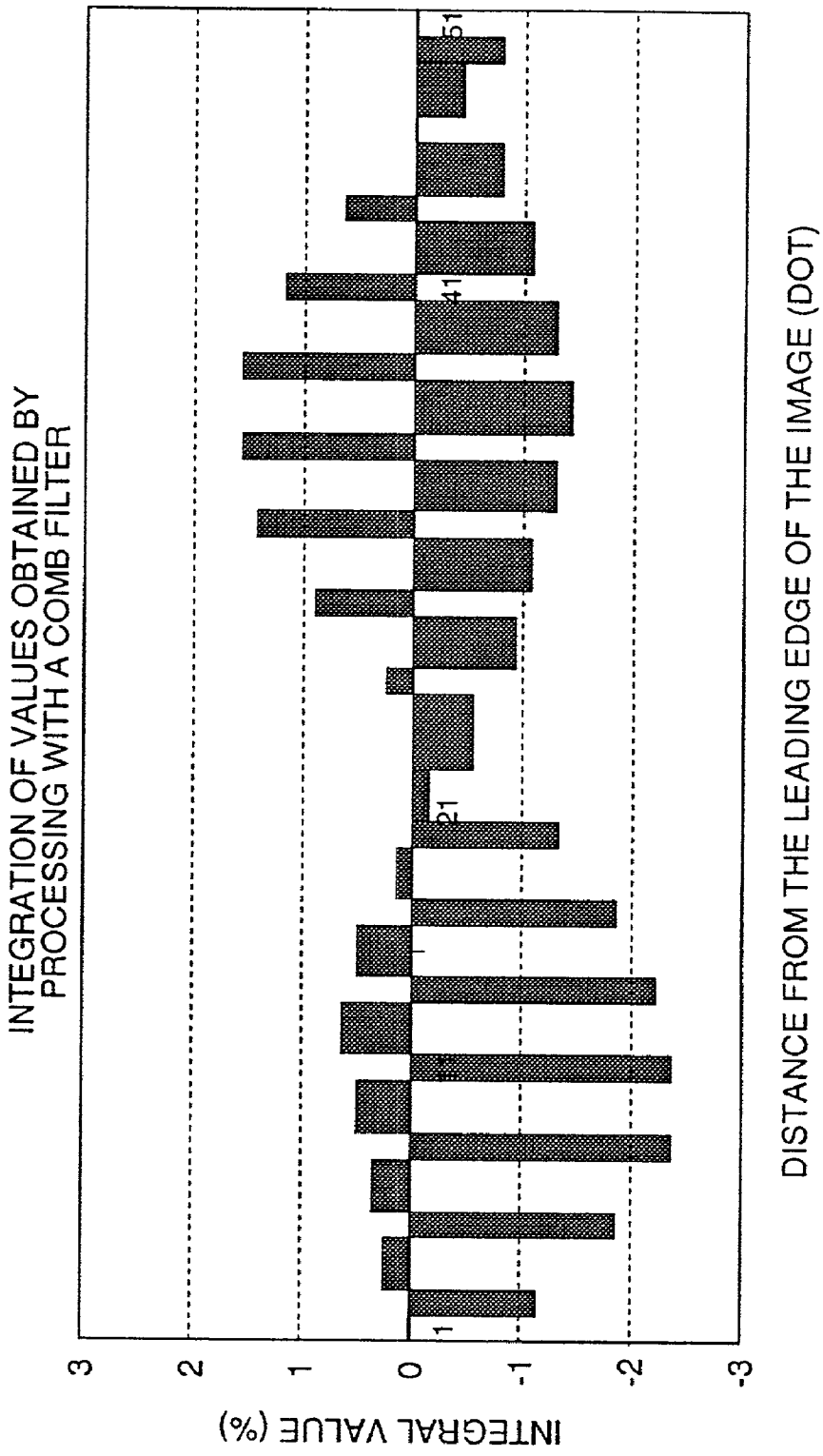

INTEGRATION OF VALUES OBTAINED BY PROCESSING WITH A COMB FILTER
INTEGRAL VALUE (%)
3
2
1
0
-1
-2
-3
1
21
41
51
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.19

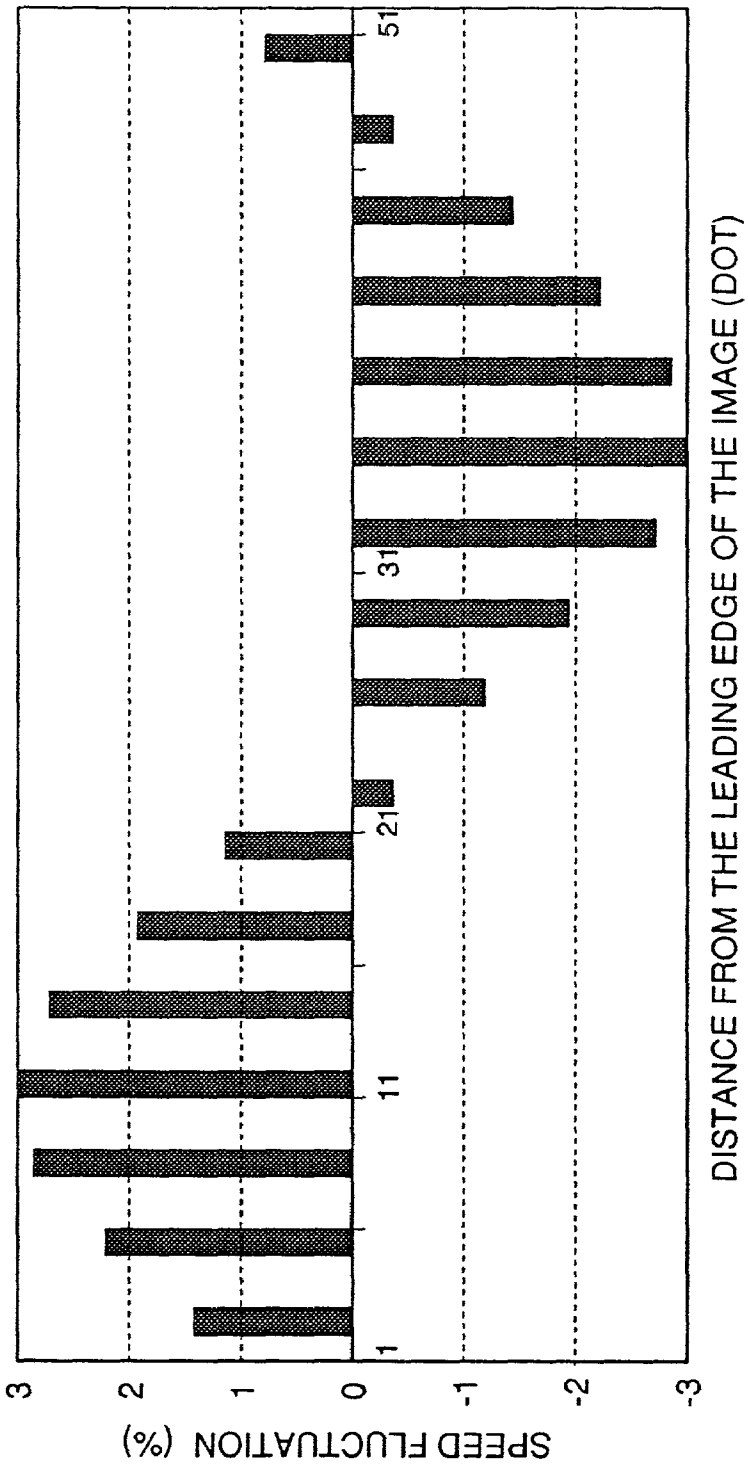

SPEED FLUCTUATION (%)
3
2
1
0
-1
-2
-3
1
11
21
31
51
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.20

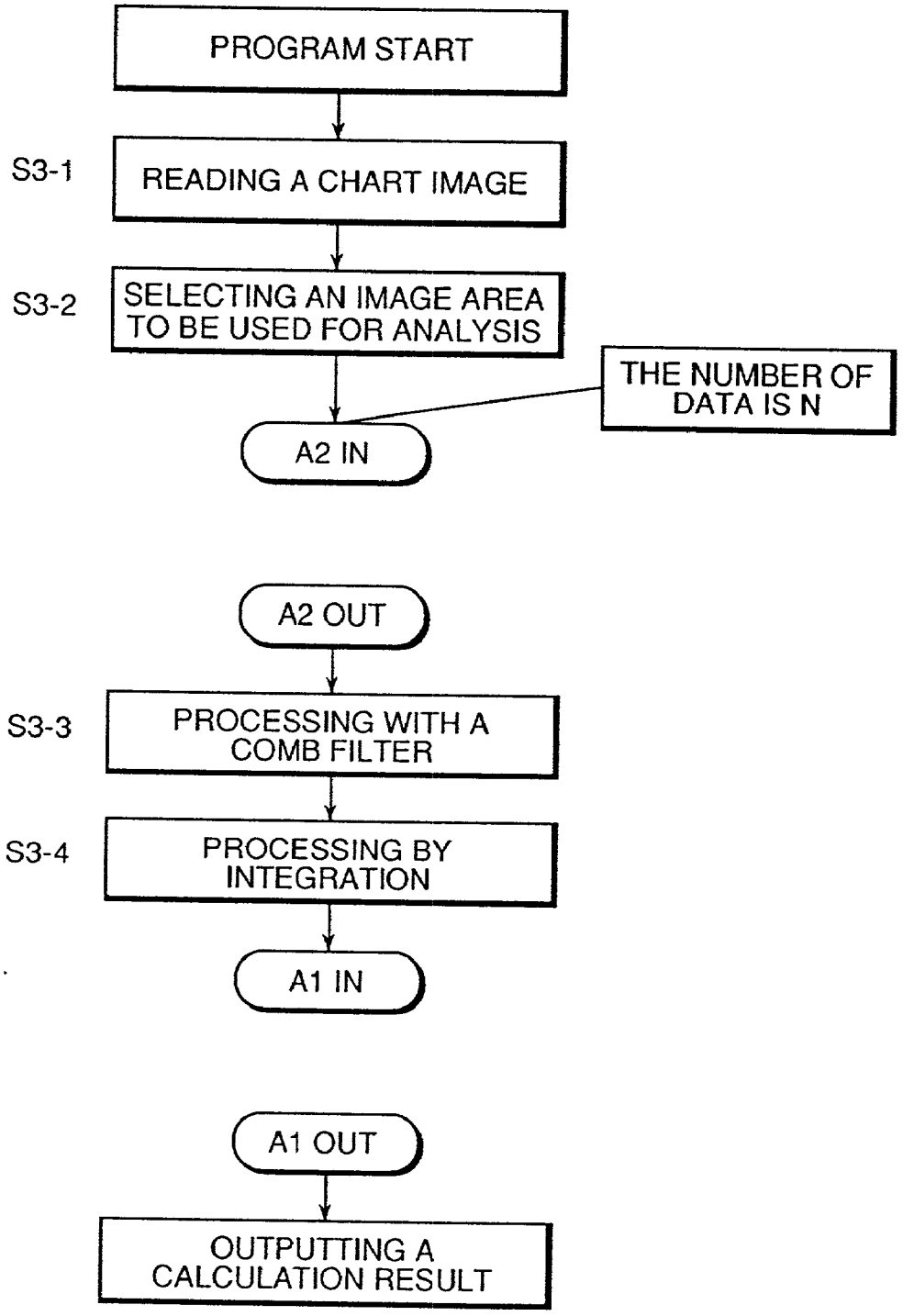

PROGRAM START
S3-1
READING A CHART IMAGE
S3-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
THE NUMBER OF DATA IS N
A2 IN
A2 OUT
S3-3
PROCESSING WITH A COMB FILTER
S3-4
PROCESSING BY INTEGRATION
A1 IN
A1 OUT
OUTPUTTING A CALCULATION RESULT

FIG.21

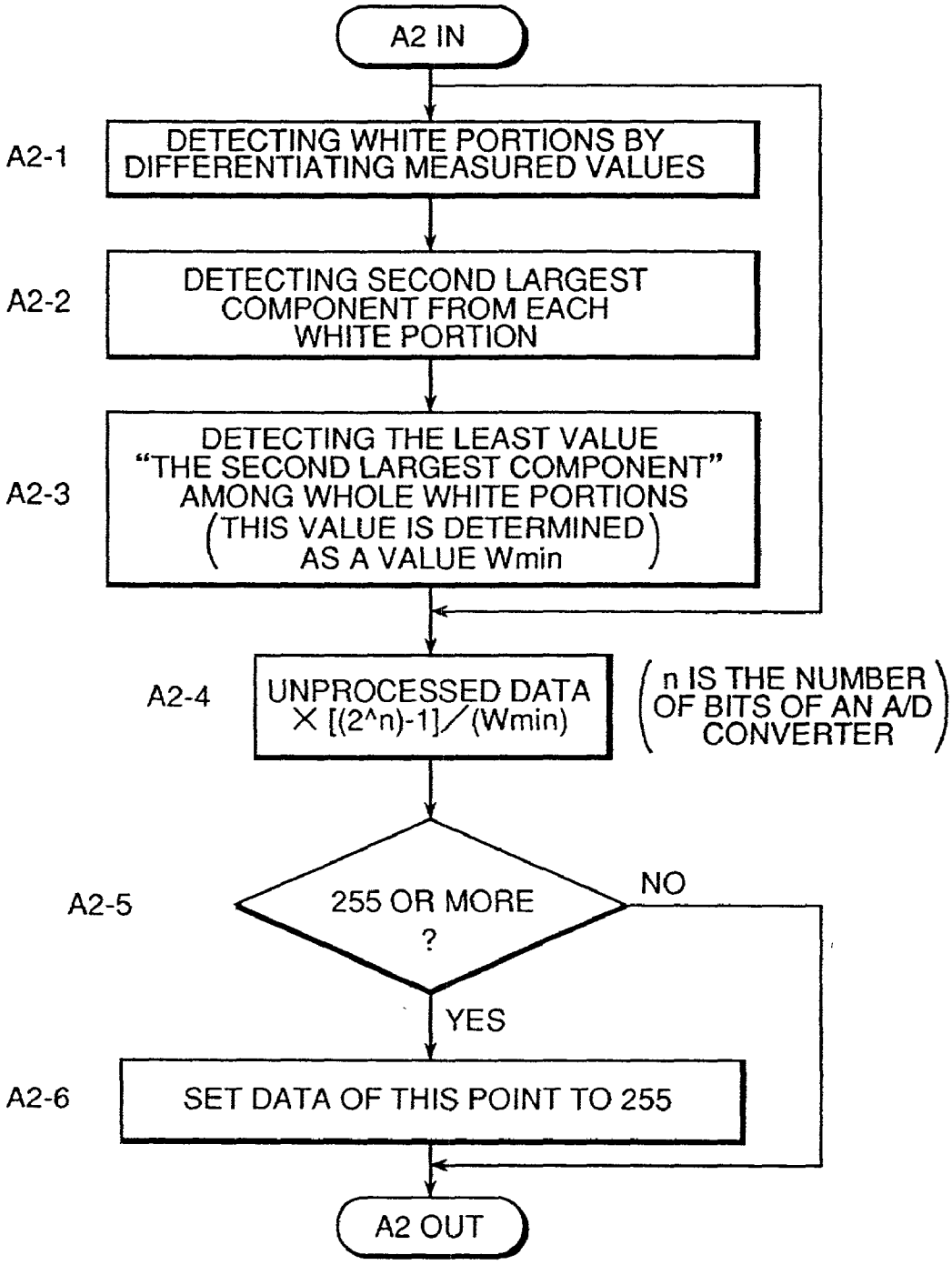

A2 IN
A2-1
DETECTING WHITE PORTIONS BY DIFFERENTIATING MEASURED VALUES
A2-2
DETECTING SECOND LARGEST COMPONENT FROM EACH WHITE PORTION
A2-3
DETECTING THE LEAST VALUE "THE SECOND LARGEST COMPONENT" AMONG WHOLE WHITE PORTIONS (THIS VALUE IS DETERMINED AS A VALUE Wmin
A2-4
UNPROCESSED DATA × [(2^n)-1]/(Wmin)
(n IS THE NUMBER OF BITS OF AN A/D CONVERTER)
A2-5
255 OR MORE ?
NO
YES
A2-6
SET DATA OF THIS POINT TO 255
A2 OUT

FIG.22

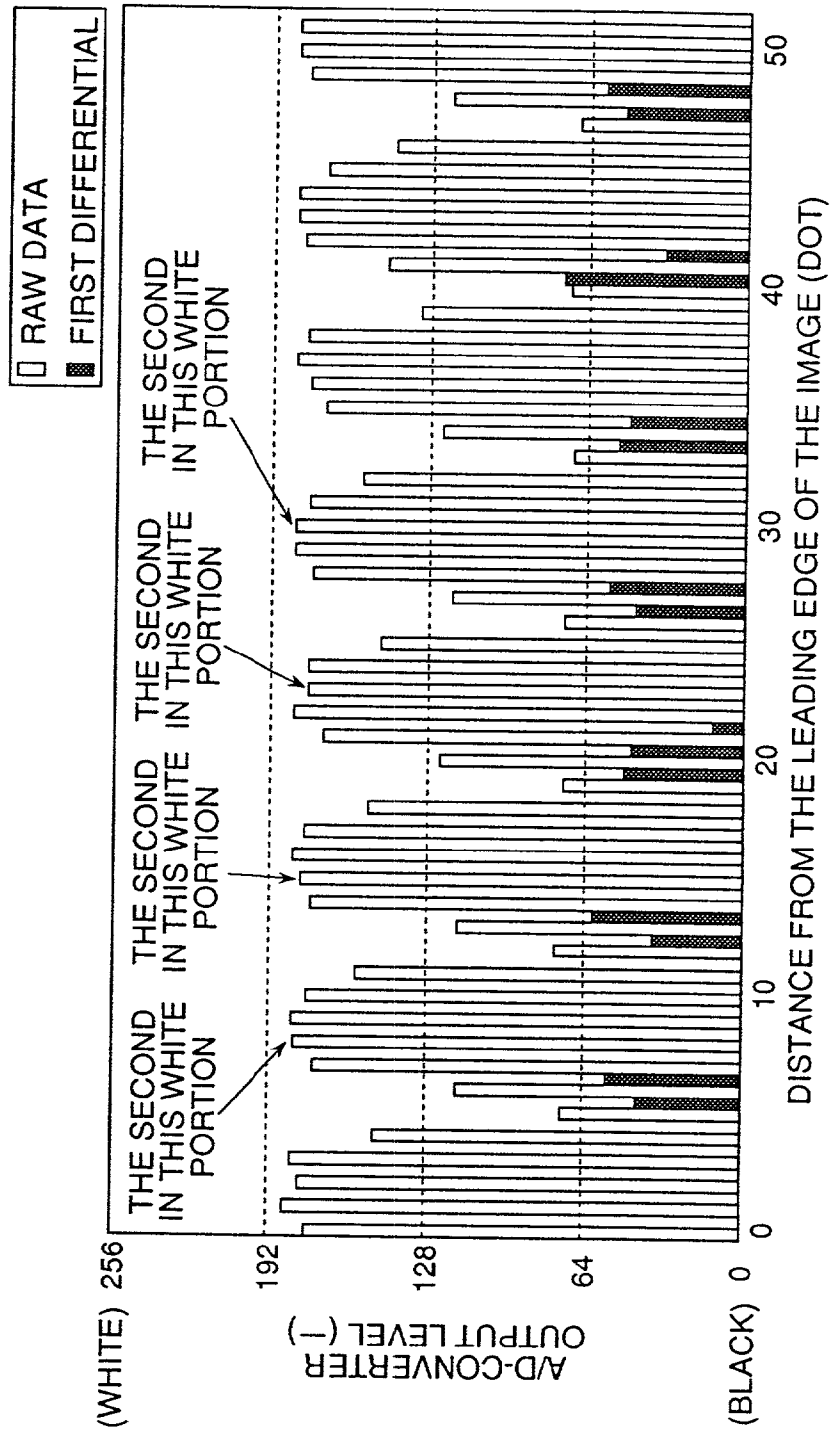

RAW DATA
FIRST DIFFERENTIAL
THE SECOND IN THIS WHITE PORTION
THE SECOND IN THIS WHITE PORTION
THE SECOND IN THIS WHITE PORTION
(WHITE) 256
192
128
64
(BLACK) 0
A/D-CONVERTER OUTPUT LEVEL (—)
0
10
20
30
40
50
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.23

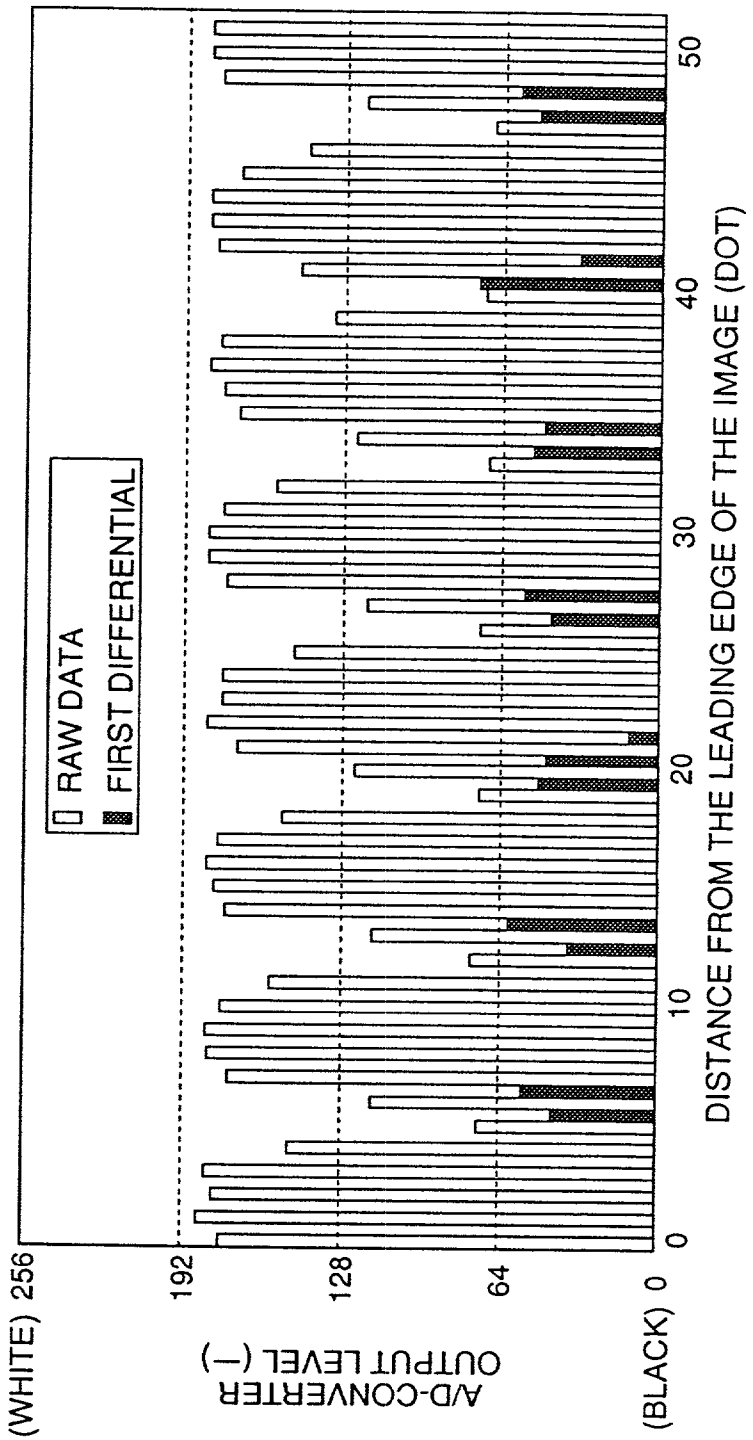

RAW DATA
FIRST DIFFERENTIAL
(WHITE) 256
192
128
64
(BLACK) 0
A/D-CONVERTER OUTPUT LEVEL (—)
0
10
20
30
40
50
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.24

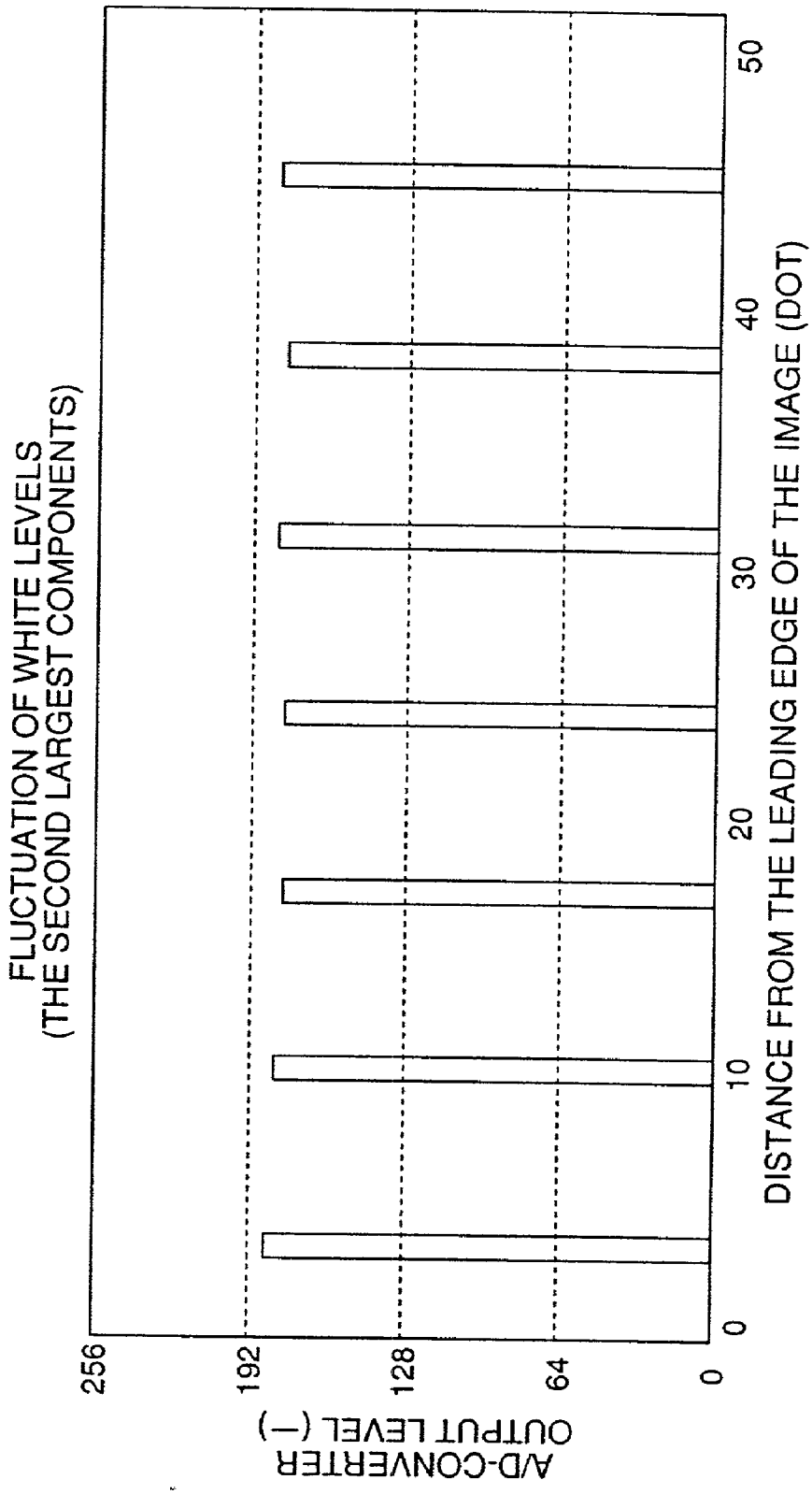

FLUCTUATION OF WHITE LEVELS
(THE SECOND LARGEST COMPONENTS)
A/D-CONVERTER
OUTPUT LEVEL (—)
256
192
128
64
0
0
10
20
30
40
50
DISTANCE FROM THE LEADING EDGE OF THE IMAGE (DOT)

FIG.25

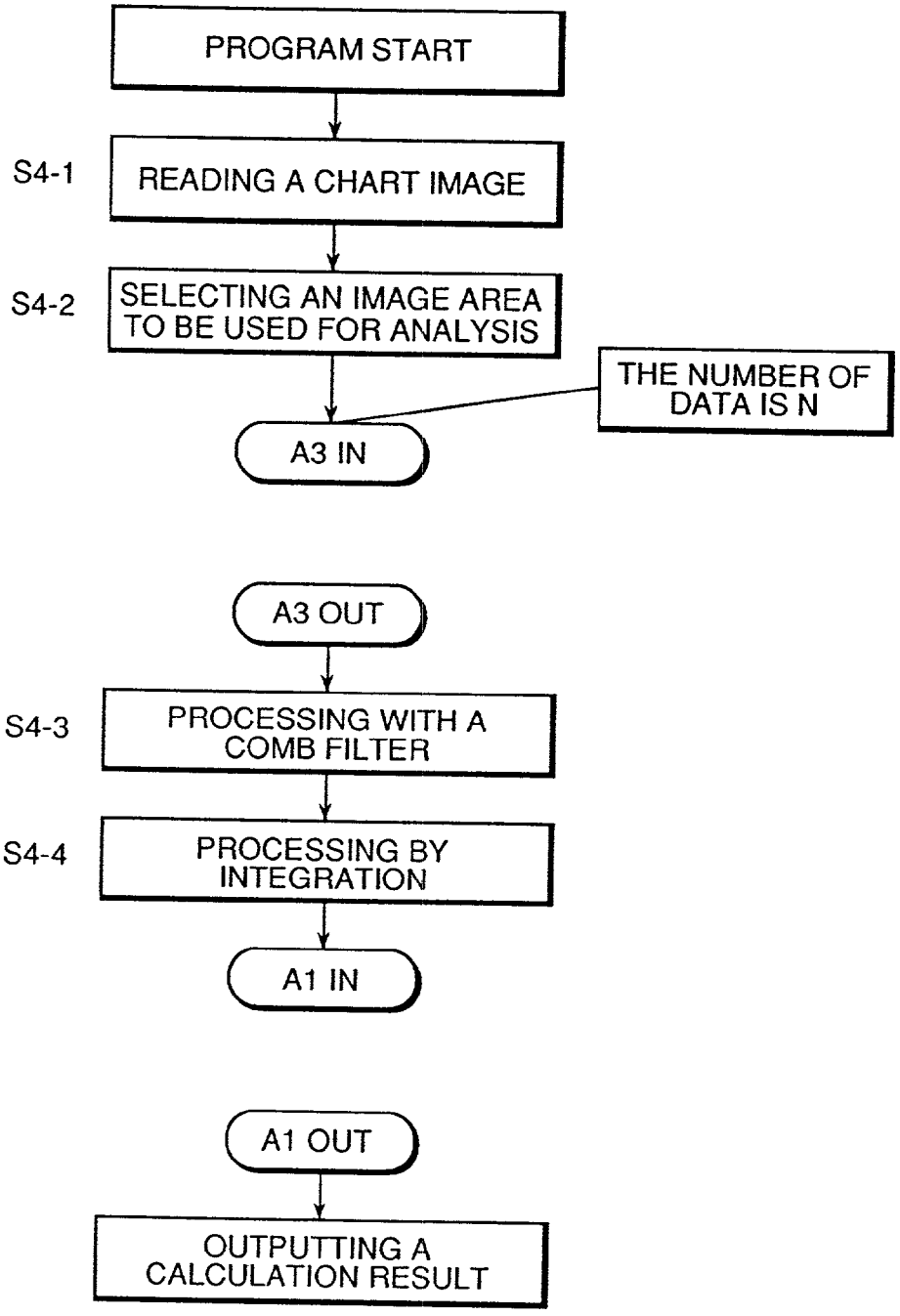

PROGRAM START
S4-1
READING A CHART IMAGE
S4-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
THE NUMBER OF DATA IS N
A3 IN
A3 OUT
S4-3
PROCESSING WITH A COMB FILTER
S4-4
PROCESSING BY INTEGRATION
A1 IN
A1 OUT
OUTPUTTING A CALCULATION RESULT

FIG.26

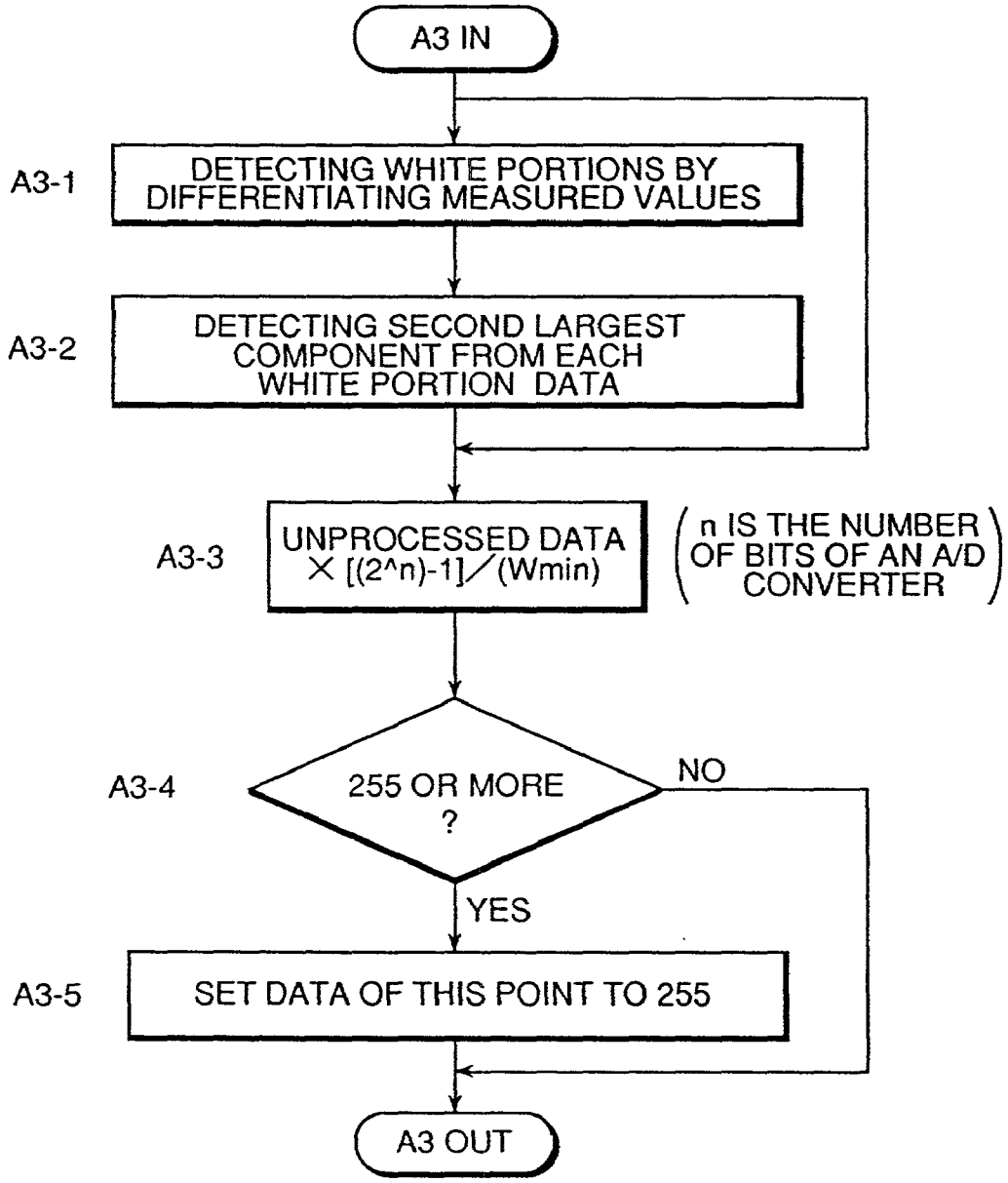

A3 IN
A3-1
DETECTING WHITE PORTIONS BY DIFFERENTIATING MEASURED VALUES
A3-2
DETECTING SECOND LARGEST COMPONENT FROM EACH WHITE PORTION DATA
A3-3
UNPROCESSED DATA × [(2^n)-1]/(Wmin)
n IS THE NUMBER OF BITS OF AN A/D CONVERTER
A3-4
255 OR MORE ?
NO
YES
A3-5
SET DATA OF THIS POINT TO 255
A3 OUT

FIG.27

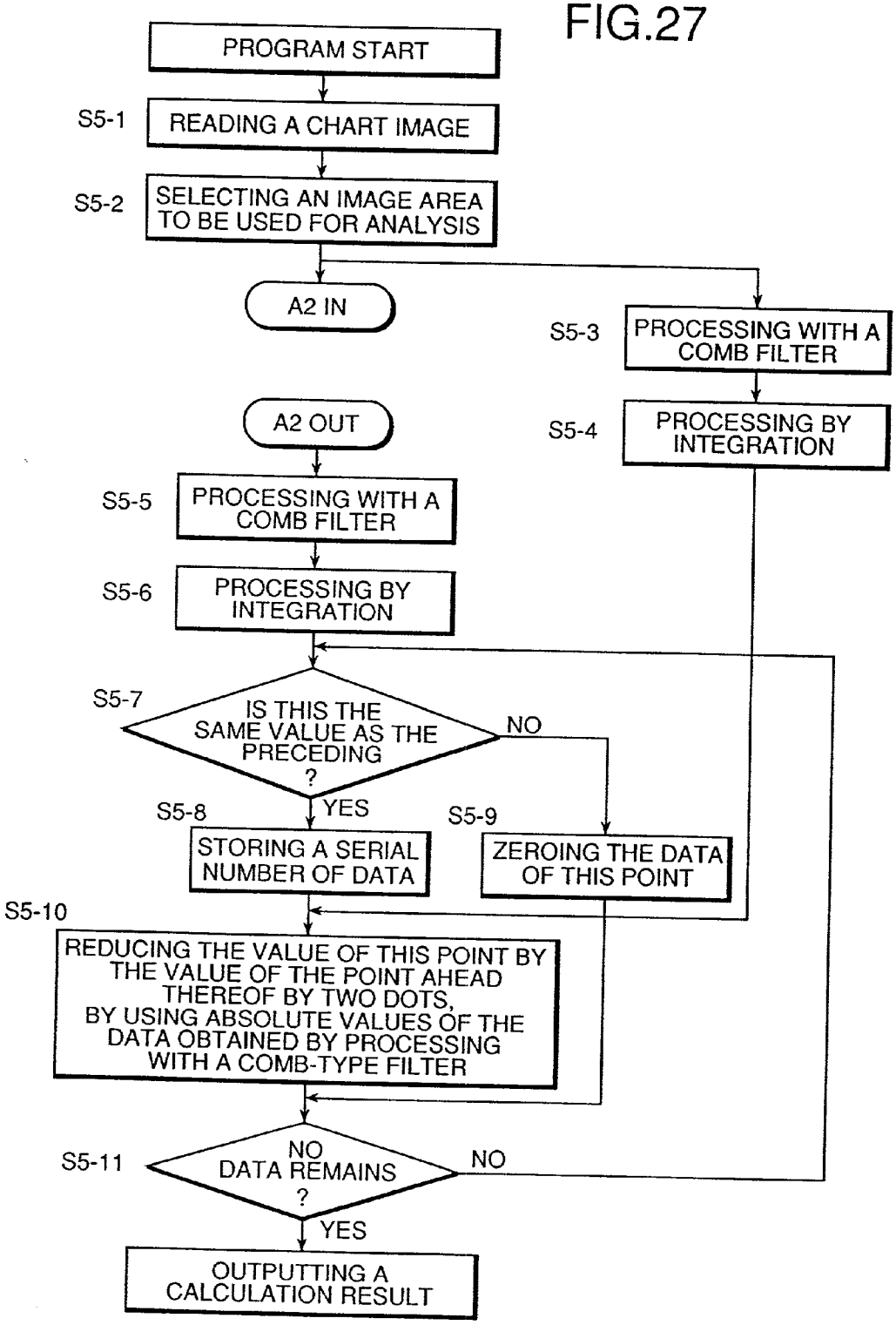

PROGRAM START
S5-1
READING A CHART IMAGE
S5-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
A2 IN
S5-3
PROCESSING WITH A COMB FILTER
S5-4
PROCESSING BY INTEGRATION
A2 OUT
S5-5
PROCESSING WITH A COMB FILTER
S5-6
PROCESSING BY INTEGRATION
S5-7
IS THIS THE SAME VALUE AS THE PRECEDING ?
NO
YES
S5-8
STORING A SERIAL NUMBER OF DATA
S5-9
ZEROING THE DATA OF THIS POINT
S5-10
REDUCING THE VALUE OF THIS POINT BY THE VALUE OF THE POINT AHEAD THEREOF BY TWO DOTS, BY USING ABSOLUTE VALUES OF THE DATA OBTAINED BY PROCESSING WITH A COMB-TYPE FILTER
S5-11
NO DATA REMAINS ?
NO
YES
OUTPUTTING A CALCULATION RESULT

FIG.28

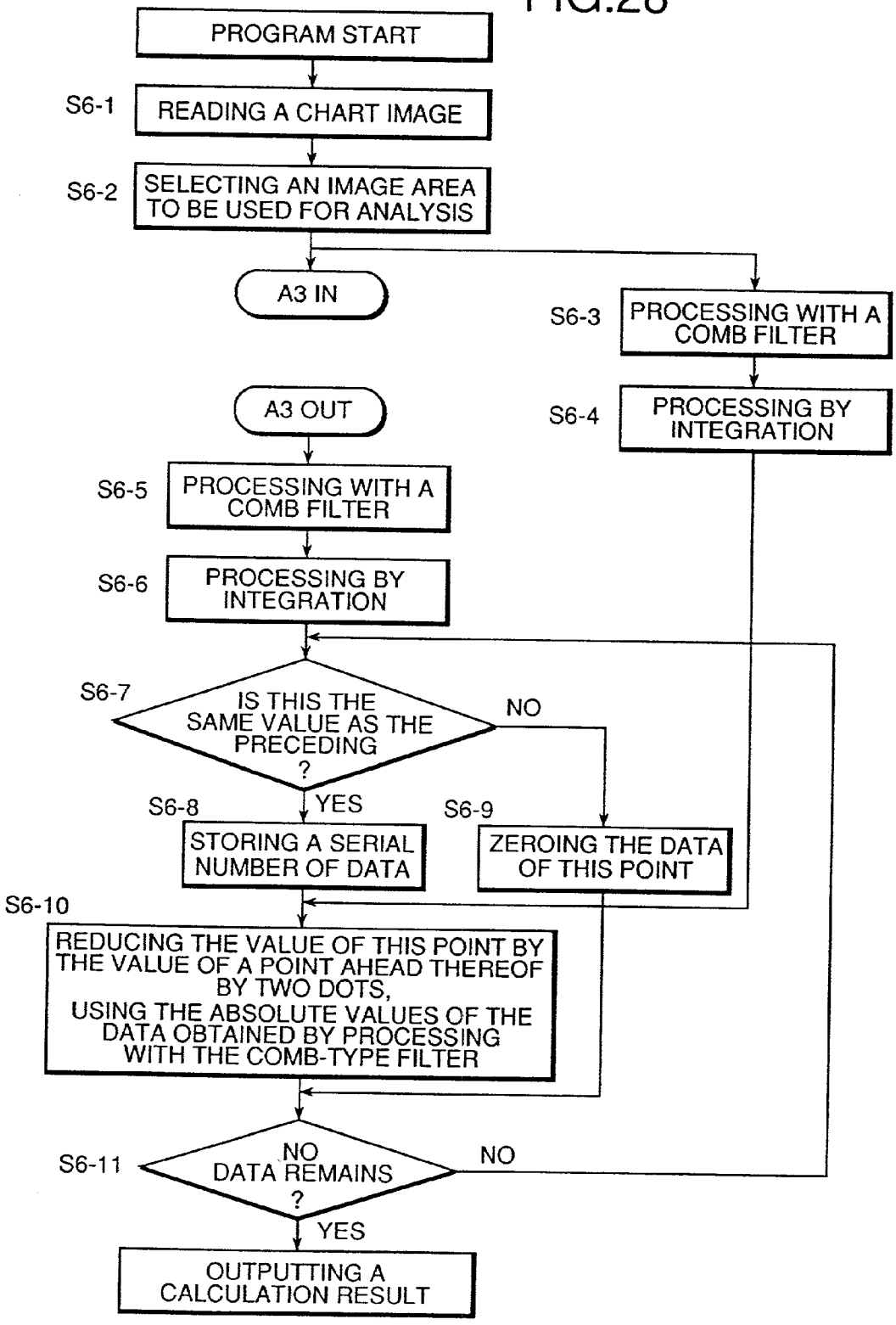

PROGRAM START
S6-1
READING A CHART IMAGE
S6-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
A3 IN
A3 OUT
S6-3
PROCESSING WITH A COMB FILTER
S6-4
PROCESSING BY INTEGRATION
S6-5
PROCESSING WITH A COMB FILTER
S6-6
PROCESSING BY INTEGRATION
S6-7
IS THIS THE SAME VALUE AS THE PRECEDING ?
NO
YES
S6-8
STORING A SERIAL NUMBER OF DATA
S6-9
ZEROING THE DATA OF THIS POINT
S6-10
REDUCING THE VALUE OF THIS POINT BY THE VALUE OF A POINT AHEAD THEREOF BY TWO DOTS, USING THE ABSOLUTE VALUES OF THE DATA OBTAINED BY PROCESSING WITH THE COMB-TYPE FILTER
S6-11
NO DATA REMAINS ?
NO
YES
OUTPUTTING A CALCULATION RESULT

FIG.29

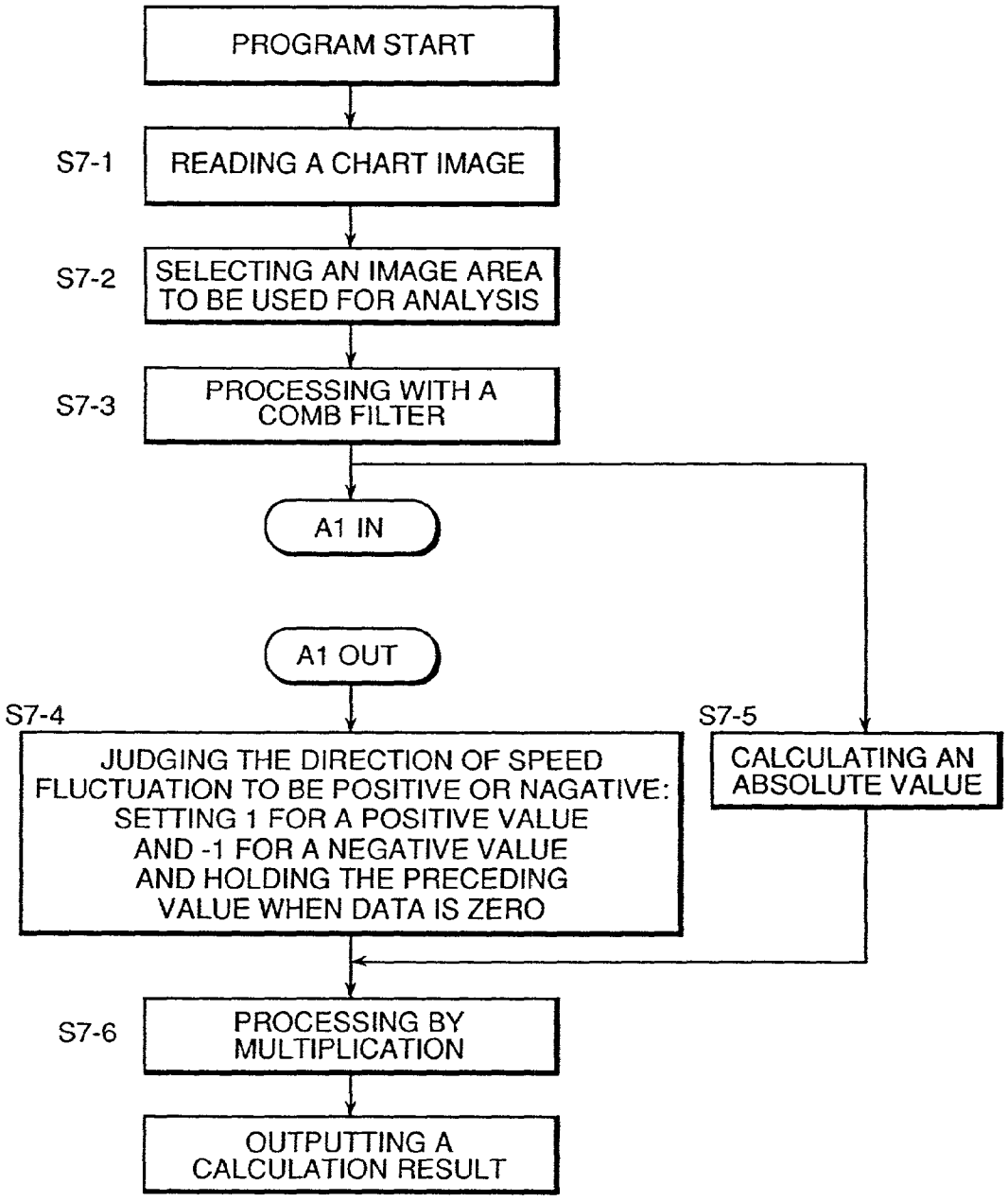

PROGRAM START
S7-1
READING A CHART IMAGE
S7-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
S7-3
PROCESSING WITH A COMB FILTER
A1 IN
A1 OUT
S7-4
JUDGING THE DIRECTION OF SPEED FLUCTUATION TO BE POSITIVE OR NAGATIVE: SETTING 1 FOR A POSITIVE VALUE AND -1 FOR A NEGATIVE VALUE AND HOLDING THE PRECEDING VALUE WHEN DATA IS ZERO
S7-5
CALCULATING AN ABSOLUTE VALUE
S7-6
PROCESSING BY MULTIPLICATION
OUTPUTTING A CALCULATION RESULT

FIG.30

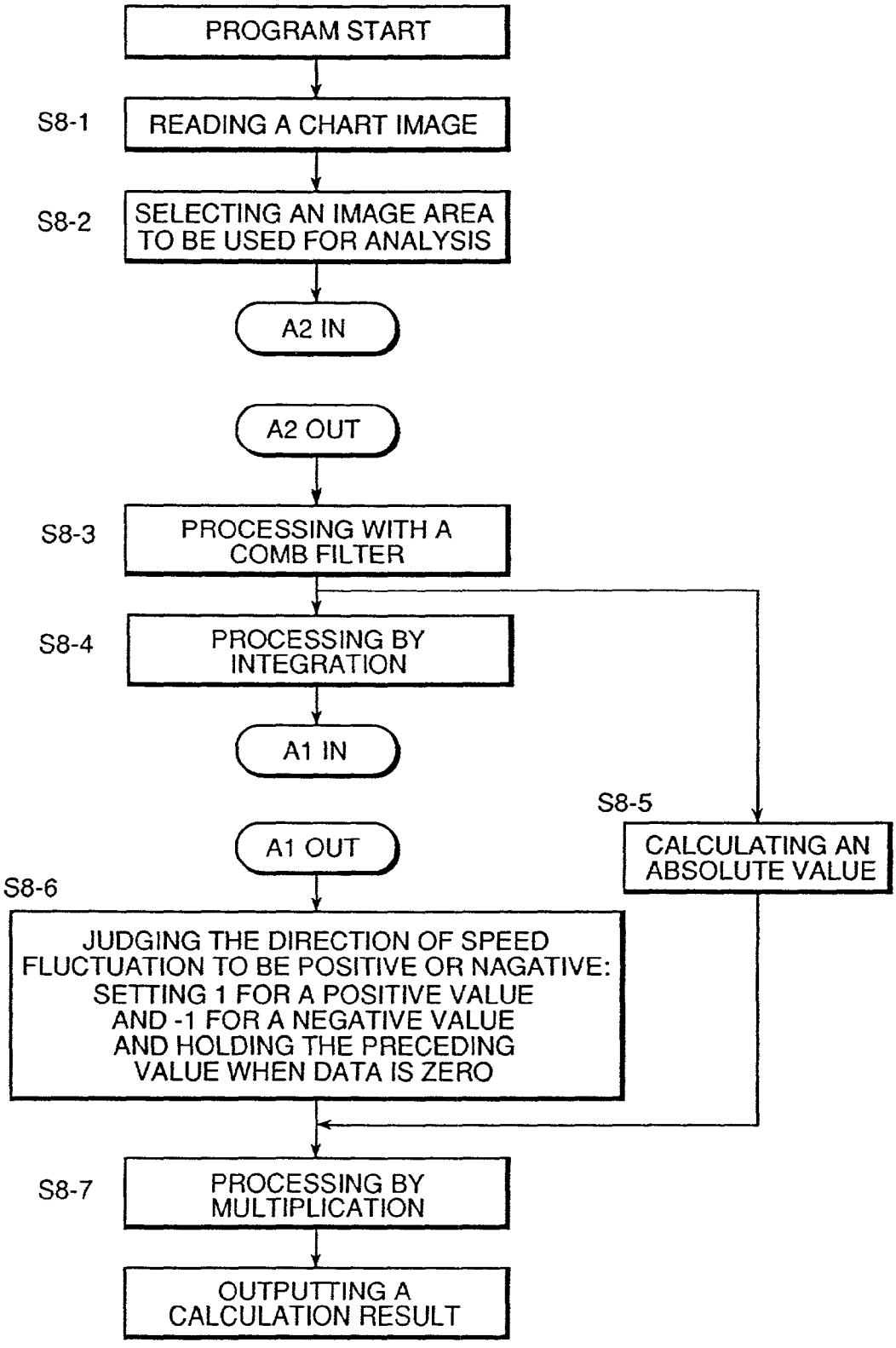

PROGRAM START
S8-1
READING A CHART IMAGE
S8-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
A2 IN
A2 OUT
S8-3
PROCESSING WITH A COMB FILTER
S8-4
PROCESSING BY INTEGRATION
A1 IN
S8-5
CALCULATING AN ABSOLUTE VALUE
A1 OUT
S8-6
JUDGING THE DIRECTION OF SPEED FLUCTUATION TO BE POSITIVE OR NAGATIVE: SETTING 1 FOR A POSITIVE VALUE AND -1 FOR A NEGATIVE VALUE AND HOLDING THE PRECEDING VALUE WHEN DATA IS ZERO
S8-7
PROCESSING BY MULTIPLICATION
OUTPUTTING A CALCULATION RESULT

FIG.31

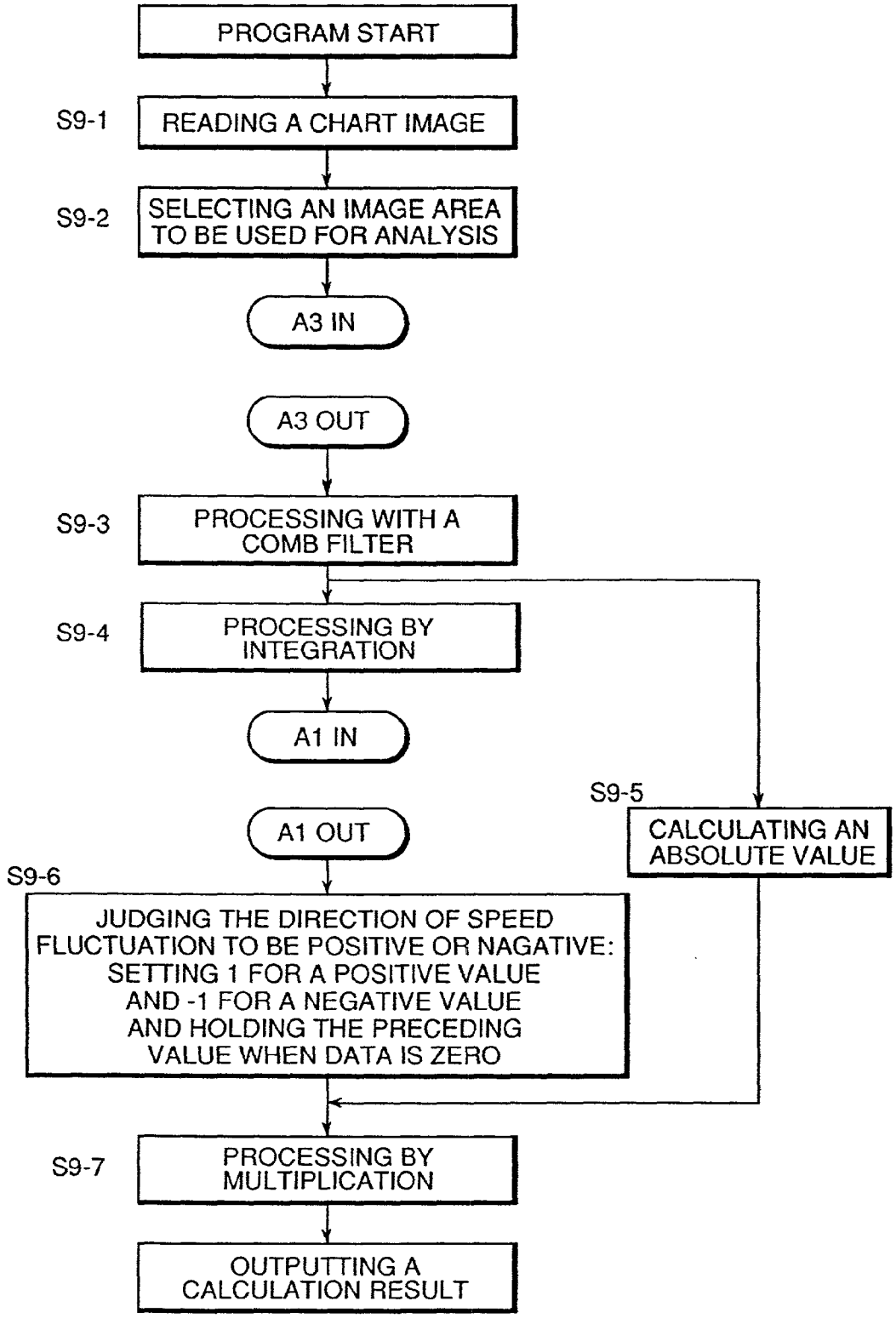

PROGRAM START
S9-1
READING A CHART IMAGE
S9-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
A3 IN
A3 OUT
S9-3
PROCESSING WITH A COMB FILTER
S9-4
PROCESSING BY INTEGRATION
A1 IN
S9-5
CALCULATING AN ABSOLUTE VALUE
A1 OUT
S9-6
JUDGING THE DIRECTION OF SPEED FLUCTUATION TO BE POSITIVE OR NAGATIVE: SETTING 1 FOR A POSITIVE VALUE AND -1 FOR A NEGATIVE VALUE AND HOLDING THE PRECEDING VALUE WHEN DATA IS ZERO
S9-7
PROCESSING BY MULTIPLICATION
OUTPUTTING A CALCULATION RESULT

FIG.32

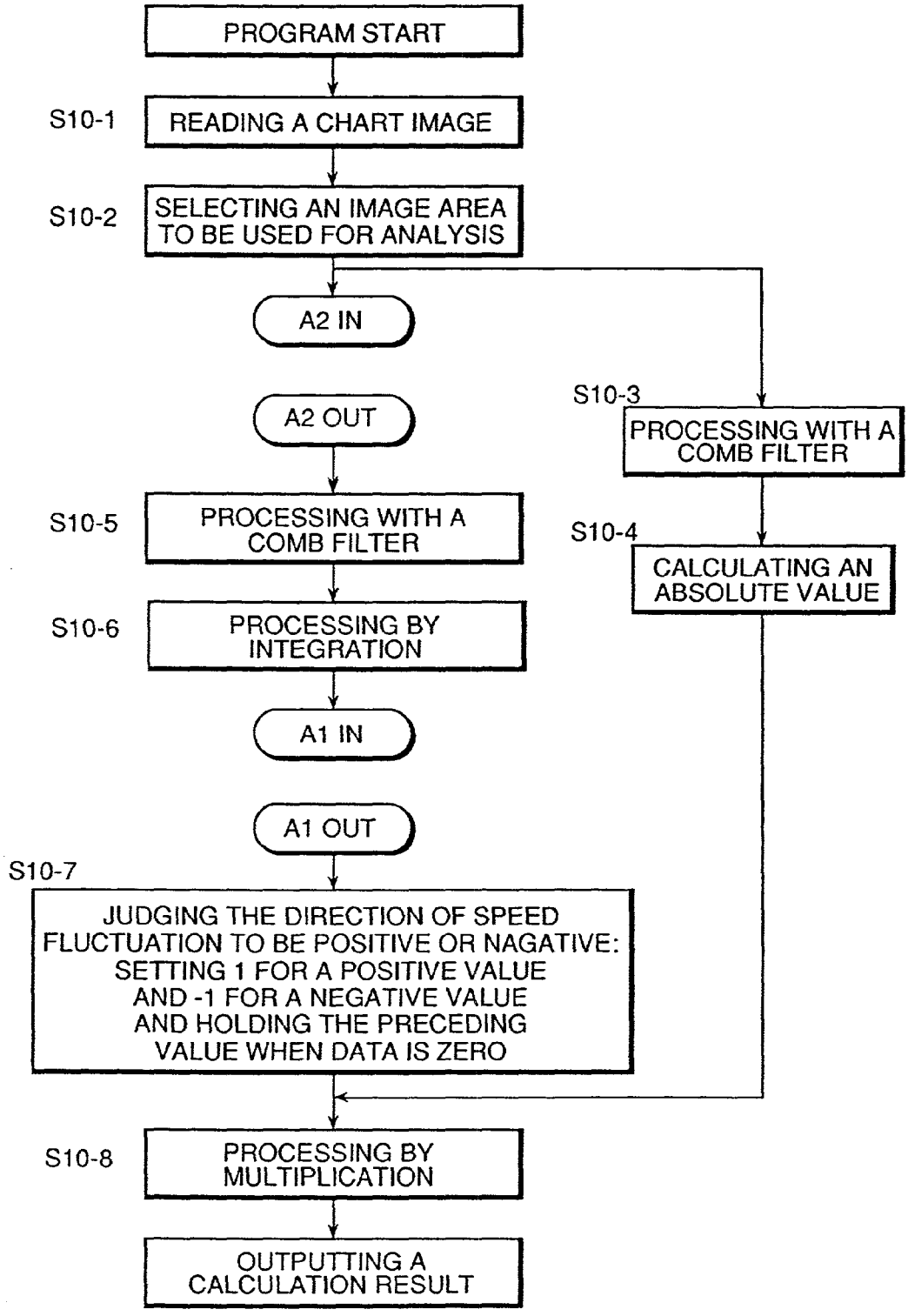
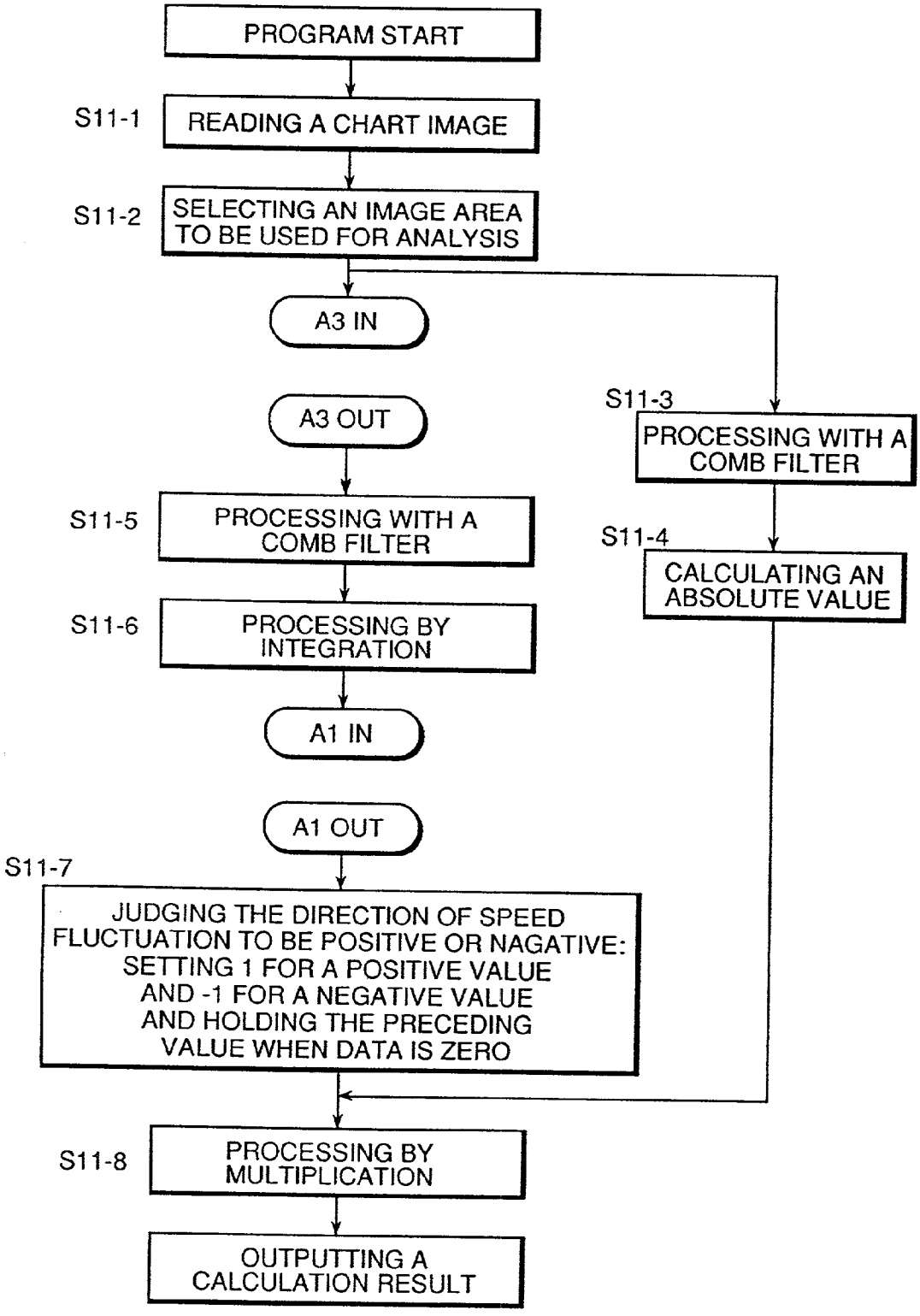

PROGRAM START
S10-1
READING A CHART IMAGE
S10-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
A2 IN
A2 OUT
S10-3
PROCESSING WITH A COMB FILTER
S10-5
PROCESSING WITH A COMB FILTER
S10-4
CALCULATING AN ABSOLUTE VALUE
S10-6
PROCESSING BY INTEGRATION
A1 IN
A1 OUT
S10-7
JUDGING THE DIRECTION OF SPEED FLUCTUATION TO BE POSITIVE OR NAGATIVE: SETTING 1 FOR A POSITIVE VALUE AND -1 FOR A NEGATIVE VALUE AND HOLDING THE PRECEDING VALUE WHEN DATA IS ZERO
S10-8
PROCESSING BY MULTIPLICATION
OUTPUTTING A CALCULATION RESULT

FIG.33


PROGRAM START
S11-1
READING A CHART IMAGE
S11-2
SELECTING AN IMAGE AREA TO BE USED FOR ANALYSIS
A3 IN
A3 OUT
S11-3
PROCESSING WITH A COMB FILTER
S11-5
PROCESSING WITH A COMB FILTER
S11-4
CALCULATING AN ABSOLUTE VALUE
S11-6
PROCESSING BY INTEGRATION
A1 IN
A1 OUT
S11-7
JUDGING THE DIRECTION OF SPEED FLUCTUATION TO BE POSITIVE OR NAGATIVE: SETTING 1 FOR A POSITIVE VALUE AND -1 FOR A NEGATIVE VALUE AND HOLDING THE PRECEDING VALUE WHEN DATA IS ZERO
S11-8
PROCESSING BY MULTIPLICATION
OUTPUTTING A CALCULATION RESULT

DOCUMENT IMAGE READING DEVICE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an image reading device for use in a facsimile, a copying machine and a scanner, which device can read an image data from a specified area of an original document by using an original document reading mechanism such as a line sensor for reading image data from an original image at a specified time-interval based on a reference clock and a mechanism for moving the original document or the image reading mechanism.

[0002] Conventional facsimiles and copying machines, which read an original document image by using an image reading system using a line sensor consisting of linearly arranged image sensors such as CCDs, involve such a common problem that a distorted image may be produced due to fluctuation (variation) of document image scanning speed since the document or the reading head is mechanically moved in the feed (vertical scanning) direction.

[0003] Japanese Laid-Open Patent Publication No. 4-196964 discloses an image reading device that can detect a change in the scanning speed (fluctuation) by using a flowchart as shown in **FIG. 1**.

[0004] The image reading device reads a document image together with an equal-pitch scale (reference scale) consisting of high-density and low-density lines of the same width, which lines are arranged alternatively at the same distance in the feed direction. Namely, its image-reading means such as a line sensor read the document image and the equal-pitch scale at the same time, detects read-time intervals of respective line-to-line distances of the scale (i.e., each distance from a high-density line to subsequent low-density line) and compares the detected time-intervals with the known reference value to determine the scanning speed fluctuation.

[0005] The essence of the art described in Japanese Laid-Open Patent Publication No. 4-196964 consists in that the fluctuation of the scanning speed is determined by reading the image together with an equal-pitch scale disposed in the feed direction and comparing read-time intervals of the scale lines with the known reference value. This method can improve the accuracy of image scanning to compensate the possible distortion of a reproduced image due to fluctuation of the scanning speed without a considerable increase of the manufacturing cost of the image reading device.

[0006] However, the line sensor used in the above-described device is driven by clock signals and reads a document image at a specified time-interval in synchronism with the clock signals.

[0007] Consequently, a change in the scanning speed may not be detected if the displacement due to the scanning speed change of the scanner is smaller than one pixel in the feed direction. To increase the resolving power of the line sensor for detecting the scanning speed fluctuation, it is necessary to considerably increase the clock frequency. This solution, therefore, is impractical in view of increasing high-frequency noise and additional cost.

[0008] In case of reading the reference line scale by using analog elements (photo diodes or photo transistors) in combination with a specialized A/D converter, time must be measured by using a high-speed A/D converter, a high-speed timer and a high-response optical device. This may also arise the problems of increasing high-frequency noise and increasing the cost.

[0009] Furthermore, the use of a higher frequency clock cannot always enable the line sensor to finely read the equal-pitch line scale for analysis of the speed fluctuation because the size of an image read by one pixel of the line sensor is determined by an optical lens system interposed between a document and the line sensor. Namely, the line sensor may not detect the scanning speed fluctuation if the displacement due to the fluctuation is smaller than one pixel in the feed direction.

[0010] The reference line scale used in the conventional image reading systems is an arrangement of lines alternating black (high-density part) and white (low-density part) with the same width. There may arise a problem that a half-pitch shift of the reading pitch frequency of a scanner in the feed direction from the frequency of the equal-pitch lines of the reference scale may result in outputting a halftone image which cannot be analyzed.

[0011] The use of an equal-pitch scale having lines with width not less than two pixels of the line sensor for solving the above problem may make the system unable to detect scanning speed fluctuation.

[0012] Analysis of the scanning speed fluctuation by integration of results of obtained by processing an image from its top with a comb filter may have an incorrect result if read image data contains erroneous data due to a small change in the density of the equal-pitch scale image and the presence of dust and noise when reading the image.

[0013] In addition, the above calculation premises that the same outputs appear continuously to represent black or white lines of the reference scale image. However, the black and white lines of the scale may have small fluctuation of output values in may case by the effect of adjustments of the line sensor and the A/D converter and the above-mentioned errors.

[0014] Therefore, the white line has width equal to two pixels can not always have the same values by two successive pixels at the output of the A/D converter. Speed fluctuation component cannot be separated and extracted if the two white lines of the reference scale have different output values.

[0015] The above problem may be avoided by applying a single correction factor to all image data so that all white parts and all black parts may have respective fixed values. However, this solution may cause partial excessive or insufficient compensation if a white shading level or a black shading level is preset to vary while the scanner scans image data in the feed direction. The accuracy of analysis may be decreased.

[0016] Furthermore, when the corrected values are not only used for separating a black line part from a white-line part but used for calculating the scanning speed fluctuation, the analysis may not attain the sufficient accuracy depending on the corrected state.

[0017] It can be also sought to observe the scanning speed fluctuation by extracting a two-dot part showing the same output values in series and determining a value of this

position by extracting an integrated value of the part exiting ahead by two dots from the extracted output value. This method, however, has a final result of subtraction at a portion from a black-line to a white-line or at a portion from a while-line to a black-line. For white or black lines each having a width of two dots or more, final values are spaced with the white or black part width, zeroing data for each spacing.

[0018] Consequently, only a part of data obtained by processing outputs of the A/D converter with a comb filter is used and remaining data is discarded. No improvement is achieved even by holding a preceding value for each zero-data part.

[0019] In other words, the analysis with a chart having a widened frequency (e.g., black line of 1 dot in width and a white line widened to x dots in width) can effectively use only 2/(x+1) of measurement results.

SUMMARY OF THE INVENTION

[0020] The object of the present invention is to provide a document-image reading device that can separate and extract a speed fluctuation component by determining a gray-level change of each scale line (not reading time-interval), analyze a state of speed fluctuation of scanning in the feed direction and, based on the analysis result, eliminate the possibility of image deformation that may be caused from the unstable factors of the driving mechanism of the device.

[0021] Namely, a speed fluctuation component is separately extracted by reading a change in gray level of respective scale lines and analyzed a speed fluctuation state of a scanner scanning in the feed direction and deformation of an image can be eliminated based on the analysis result.

[0022] Another object of the present invention is to provide a document-image reading device that can separately extract speed fluctuation of its scanner when working with an equal-pitch scale representing alternations of a black line of one pixel in width and a white line of two pixels in width.

[0023] Another object of the present invention is to provide a document-image reading device that can perform high-accuracy high-resolution analysis of the scanning speed fluctuation with no affection of partial abnormal data to an entire analysis result.

[0024] Another object of the present invention is to provide a document-image reading device that can accurately analyze the speed fluctuation without decreasing the accuracy due to dispersion of reading a scale image.

[0025] Another object of the present invention is to provide a document-image reading device that can accurately analyze the speed fluctuation without decreasing the accuracy in the case when a shading level varies during scanning operation.

[0026] Another object of the present invention is to provide a document-image reading device that can always perform accurate correction of image data, eliminating the possibility of decreasing the accuracy of analysis depending the correction state.

[0027] A document-image reading device of the present invention comprises document-image reading means for reading a document image data at a specified interval given by a reference clock by moving the document-image reading means or the document in the feed direction, which means is further provided with a reference chart reading means for reading a reference chart portion representing alternations of a high-density division and a low-density division arranged in the feed direction at an interval equal to a least pitch readable by the document-image reading means and processing means for processing image data read from the reference chart by using a comb filter followed by integration.

[0028] The construction of the device can attain higher accuracy of the speed fluctuation analysis in comparison with a method for measuring time-intervals between lines of an image read from a reference chart (equal-pitch scale) portion.

[0029] A document-image reading device of the present invention comprises document-image reading means for reading a document image data at a specified interval given by a reference clock by moving the document-image reading means or the document in the feed direction and is featured in that the document-image reading means is further provided with a reference chart reading means for reading a reference chart portion representing alternations of a high-density division and low-density division, in which every high-density or low-density divisions has a width equal to a least readable pitch and every low-density division has a width equal to an integer-multiple of the least readable pitch, thus the high-density divisions and low-density divisions alternately arranged one after another at respective equal intervals in the feed direction, and processing means processing the image data read from the reference chart by using a comb filter followed by integration, extracting continuous detection of the substantially same integrated values by the integer number of times and determining an integrated value at the extracted position by reducing the extracted integrated value by an integrated value at an upstream point at a distance of the integer-multiple of the least-readable pitch along the feed direction.

[0030] This device can therefore eliminate the possibility of making the image data of the equal-pitch scale become an unanalysable 50% gray scale when the reading pitch of the CCD in the feed direction deviates from the pitch of the equal-pitch scale by a ½ dot.

[0031] Furthermore, the device can obtain higher accuracy of analysis because the analysis can be made by subtracting only peripheral portions when integrated values are the same subsequent values. Namely, the affection of an abnormal value of the partial image on a whole analysis result can be surely avoided.

[0032] A document-image reading device of the present invention comprises a document-image reading means for reading image data from a document at a specified time-interval based on a reference clock by moving said document image reading means or the document in a feed scanning direction and is featured in that the document-image reading means is further provided with reference-chart reading means for reading a reference chart representing alternations of a low-density or high-density divisions with a width equal to a least readable pitch and a high-density or low-density division with a width equal to an integer-multiple of the least readable width along the feed

direction and image-data processing means for separating the high-density divisions and low-density divisions from the read image-data, determining a correction factor by which image data for all low-density or high-density divisions or respective low-density or high-density divisions can be corrected to have a constant value, multiplying the image data by the correction factor, processing the image data read from the reference chart by using a comb filter, performing integral calculations on the filtered data, extracting continuous detection of the substantially same integrated value by the integer number of times and determining an integrated value at the extracted position by reducing an integrated value, said value extracted from uncorrected image data by an integrated value of an upstream point at a distance of the integer-multiple of the least-readable pitch along the feed direction.

[0033] This device can therefore analyze the speed fluctuation of the document-image reading means (e.g., a scanning device) even when the white levels of the equal-pitch scale image cannot indicate a constant value due to insufficient adjustment of a signal processing system for an image reading section of the scanner. Furthermore, its calculation load can be lessened since only one correcting value is used for correcting the white levels of the whole image.

[0034] The device can also examine the white levels of the equal-pitch scale image data and determine a specified correction value separately for each white portion, by which the portion may be corrected to have a preset constant value. This makes it possible to analyze the speed fluctuation without decreasing the analysis accuracy even if the white level of the scanner varies during a scan.

[0035] In this instance, the calculation load increases but the white level is real time measured and a correction value can be immediately determined with no need of waiting until the whole image data are measured. The speed fluctuation analysis result can be, therefore, outputted just after reading the image.

[0036] A document-image reading device of the present invention is further featured in that the image-data processing means is provided with processing means for determining a correction factor, multiplying image data by the correction factor, processing the corrected image data with a comb filter and by integration, detecting the substantially same values in succession by the integer-number of times, reducing an integrated value, said value extracted from the uncorrected image data, by an integrated value found at a upstream point in the feed direction at a distance of the integer-multiple of the least readable pitch and determining the reduced value as an integrated value of the extracted point.

[0037] The device uses corrected data only for determining the conditions of the speed fluctuation analysis and uses uncorrected data for determining speed fluctuation, then determines correction coefficients that make all white (or black) portions have a constant value. It can therefore realize higher accuracy of the speed fluctuation analysis and less amount of calculation. The real time processing is also possible by determining correction values for respective white (or black) portions although the calculation amount increases.

[0038] A document-image reading device of the present invention is further featured in that image-data processing means processes image data with a comb filter followed by calculation of absolute values of the filter-processed data and temporarily store the processing result in storing means, and, at the same time, performs processing a read image of a reference chart with a comb filter and by integration, detects the substantially same values in series by the integer-multiple times, reducing an extracted integrated value by an integrated value found at the upstream-side point in the feed direction at a distance of the integer-multiple of the least readable pitch, determines the reduced value as an integrated value of the extracted point by setting 1 for a positive resultant, 0 for a zero resultant and −1 for a negative resultant, then multiplies the resultant values by the processed results temporarily stored in the storing means.

[0039] The device calculates speed fluctuation by using absolute values of the resultant data obtained by processing the output of A/D converter with a comb filter. Consequently, the finally obtained result of analysis may reflect each part changing from a white portion to a black portion and/or each part changing from a black portion to a white portion and, therefore, can attain increased accuracy.

[0040] The processing may also be conducted after correction of white shading for all image data by using the same correction factor. By doing so, the speed fluctuation analysis can be done even if the white levels of the equal-pitch scale did not meet a constant value due to insufficient adjustment of an image-reading signal-processing system of the scanner. Furthermore, the white level of the equal-pitch scale image-data is corrected by using only one correction value for a whole image, thus achieving the saved amount of calculation.

[0041] A document-image reading device of the present invention is further featured in that absolute values obtained by processing with a comb filter before shading correction are used for multiplication.

[0042] Accordingly, the corrected values are used only for separating white portions from black portions and the uncorrected data is used for calculation of the speed fluctuation. The device can therefore attain high accuracy of analysis.

[0043] The device can determine correction factors for correcting respective white line portions to have a full-bit output of an A/D converter and can separately correct the respective portions with corresponding correction factors since the corrected values are used only for separation of white portions from black portions and not-yet-corrected data is used for calculating the speed fluctuation.

[0044] Therefore, this device can accurately analyze the speed fluctuation even if the shading level varies during scanning operation, attaining high accuracy of analysis.

BRIEF DESCRIPTION OF DRAWINGS

[0045] **FIG. 1** is a flow chart of a prior art.

[0046] **FIG. 2** is a view showing a construction of an image reading device embodying the present invention.

[0047] **FIG. 3** is a view showing a construction of an image reading device embodying the present invention.

[0048] **FIG. 4** is a view showing a construction of an image reading device embodying the present invention.

[0049] **FIG. 5** is illustrative of an image analyzing chart **17** for an embodiment of the present invention.

[0050] **FIG. 6** is a conceptual illustration of a technique applied in an embodiment of the present invention.

[0051] **FIG. 7** depicts a time relation of signals in an embodiment of the present invention.

[0052] **FIG. 8** shows a construction of an image analyzing chart **17** used in an embodiment of the present invention.

[0053] **FIG. 9** is a flow chart of an embodiment of the present invention.

[0054] **FIG. 10** depicts simulation data representing a basic concept of an embodiment of the present invention.

[0055] **FIG. 11** depicts simulation data representing a basic concept of an embodiment of the present invention.

[0056] **FIG. 12** depicts simulation data representing a basic concept of an embodiment of the present invention.

[0057] **FIG. 13** depicts simulation data representing a basic concept of an embodiment of the present invention.

[0058] **FIG. 14** depicts simulation data representing a basic concept of an embodiment of the present invention.

[0059] **FIG. 15** shows a construction of an image analyzing chart **17** used in an embodiment of the present invention.

[0060] **FIG. 16** is a flow chart of an embodiment of the present invention.

[0061] **FIG. 17** is a flow chart of an embodiment of the present invention.

[0062] **FIG. 18** depicts an analyzing method used in an embodiment of the present invention.

[0063] **FIG. 19** depicts an analyzing method used in an embodiment of the present invention.

[0064] **FIG. 20** is a flow chart of an embodiment of the present invention.

[0065] **FIG. 21** is a flow chart of an embodiment of the present invention.

[0066] **FIG. 22** depicts an analyzing method used in an embodiment of the present invention.

[0067] **FIG. 23** depicts an analyzing method used in an embodiment of the present invention.

[0068] **FIG. 24** depicts an analyzing method used in an embodiment of the present invention.

[0069] **FIG. 25** is a flow chart of an embodiment of the present invention.

[0070] **FIG. 26** is a flow chart of an embodiment of the present invention.

[0071] **FIG. 27** is a flow chart of an embodiment of the present invention.

[0072] **FIG. 28** is a flow chart of an embodiment of the present invention.

[0073] **FIG. 29** is a flow chart of an embodiment of the present invention.

[0074] **FIG. 30** is a flow chart of an embodiment of the present invention.

[0075] **FIG. 31** is a flow chart of an embodiment of the present invention.

[0076] **FIG. 32** is a flow chart of an embodiment of the present invention.

[0077] **FIG. 33** is a flow chart of an embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

[0078] A flow chart of the present invention is described below with reference to accompanying drawings.

[0079] A scanner having a flat bed for placing thereon a document and a charge coupled device (CCD) for reading the document image will be employed for the sake of explanation of the present invention and is not intended to limit the scope and aspects of the present invention.

[0080] It is of course possible to embody the present invention as various kinds of document reading devices which can read an entire or a specified image area of a document **1** with a document reading mechanism using a line sensor **10** or the like by moving the document or the reading mechanism. Examples are digital devices such as copying machines, facsimiles and scanners.

[0081] **FIG. 2** shows the construction of an image reading means used in a scanner or a copying machine having a flat bed for placing a document thereon.

[0082] The document reading device is switched on after placing a document **1** is placed on the flat bed (glass plate) **2**. A light source **3** switched on and a lamp unit **5** moves from the left to the right as shown in **FIG. 2**. (This direction is the feed direction of a line sensor **10** to be described later.)

[0083] Simultaneously, a mirror unit **8** consisting of a second mirror **6** and a third-mirror **7** moves in the same direction at a speed corresponding to a half speed of the lamp unit **5**, maintaining a constant distance between the document bed **2** and the line sensor **10**.

[0084] Light emitted from the light source **3** irradiates the document **1** and then travels the first mirror **4**, second mirror **6**, third mirror **7** and a lens **9** and reaches the line sensor **10** as shown by arrows.

[0085] The line sensor **10** converts image information of the document **1** into an electric signal which is then converted by an A/D converter **11** into a digital signal and transmitted to an image processing section.

[0086] Referring to FIGS. **5** to **7**, the affection of the speed fluctuation of the document image reading means while reading a chart **17** having alternating white and black lines of the same width is described as follows:

[0087] **FIG. 5** illustrates a speed fluctuation analyzing chart **17** showing alternations of white line of 1 pixel thick and black line of 1 pixel thick. Another chart may be used if the line sensor **10** can have two kinds of distinctive outputs (densities) even if the scanning speed varies. For example, a chart having, as high-density parts, halftone lines instead of black lines.

[0088] The chart **17** is read by the image reading means in such a way that the longitudinal direction of the chart may meet with the feed direction of the image reading means.

[0089] Data by one pixel in the main scanning direction and by one line in the feed direction is extracted from the read image-data of the chart **17** as shown in **FIG. 6**. In this instance, the image-data output from the A/D converter **11** (8 bits) may show an ideal arrangement of alternating white (value "255") and black (value "0") lines.

[0090] The image-reading means (CCD) varying its scanning speed fluctuation in the feed direction cannot distinguish between the white line and the black line. It reads a part of a white line and a part of a black line at the same time.

[0091] As the result of the above, white line value "255" and black line value "0" may be, for example, of "248" and "7" respectively by being affected speed fluctuation. The changes of the optical density values of the read image were resulted from the scanning speed fluctuation of the image reading means in the feed direction.

[0092] The present invention is intended to analyze the speed fluctuation of the image reading means in the feed direction by detecting variations of the optical density values of the chart image.

[0093] [First Embodiment of the Present Invention]

[0094] **FIG. 8** shows a format of an analysis chart **17** used in the first embodiment of the present invention and **FIG. 9** shows a read-image processing flowchart.

[0095] This embodiment uses the chart **17** having alternations of a white line and a black line, each line having width of 1 pixel dot of a CCD, as shown in **FIG. 8**. The chart has a standard width of 400 dpi or 600 dpi for the image reading devices. Charts of other widths, e.g., higher-resolution type or other resolutions, can be also used in the same manner.

[0096] An image of the chart **17** is read by image reading means (to be analyzed). An output of the CCD of the image reading means is converted by an A/D converter **11** into a digitized image. The data of the digitized image is processed by conducting operations according to the flowchart of **FIG. 9** to obtain an analysis result.

[0097] Referring to **FIG. 9**, the processing is described in detail as follows:

[0098] At Step **S1-1**, the image-reading means reads the analysis chart **17** and the A/D converter **11** converts the read data into digital data.

[0099] At Step **S1-2**, only image-data read through any one of many pixels in the CCD is extracted from all the read image-data.

[0100] The same result can be obtained when any of the CCD pixels is initially aimed and the data digitized through A/D conversion of that CCD pixel output is directly used.

[0101] Consequently, the extracted data has a width of 1 pixel (dot) in main scanning direction of the CCD and a length of any selected number of pixels.

[0102] The extracted image data includes image data containing a speed fluctuation component. Therefore, the initial chart data must be removed from the obtained image data to extract only the speed fluctuation component.

[0103] At Step **S1-3**, the initial chart data is removed from the extracted image data by using a comb filter. In this embodiment, the data extracted at Step **S1-2** is processed with a two-dot cycle comb filter according to the following expression:

$$R1=D(n-1)-D(n),$$

[0104] where R is a calculation result and D(n) is image data existing at n-th position from the top.

[0105] At the same step, an obtained value of the speed fluctuation is converted into a value in percentage according to the following equation:

$$R2=-100GvR1/(2^n)/C,$$

[0106] where n is the number of bits of the A/D converter **11** and C is a cycle of the chart **17**.

[0107] At Step **S1-4**, the calculation resultant values of Step **S1-3** are summed (integrated) from the top.

[0108] The speed fluctuation component of the image reading means is separately extracted by the above calculation.

[0109] The above operation process is explained according to a simulation analysis.

[0110] **FIG. 10** shows the optical density variation of the chart **17** of **FIG. 8** in the feed direction.

[0111] If the image reading means has speed fluctuation as shown in **FIG. 11** when scanning an image in the feed direction, the A/D converter outputs density variation of the read chart image as shown in **FIG. 12**. The output is processed with a comb filter (Step **S1-3** in **FIG. 9**) to obtain a result as shown in **FIG. 13**.

[0112] The obtained result of **FIG. 14** is further processed by Step **S1-4** (**FIG. 9**) for extracting speed fluctuation components. (It is apparent from the comparison of **FIG. 11** with **FIG. 14** that extracting speed fluctuation has attained by processing image data.)

[0113] [Second Embodiment of the Present Invention]

[0114] The second embodiment of the present invention uses another analysis chart **17** which is different from that used in the first embodiment. Accordingly, the flowchart of **FIG. 9** cannot be directly applied to the second embodiment.

[0115] **FIG. 15** shows a format of an analysis chart **17** used in the second embodiment of the present invention and FIGS. **16** and **17** show a flowchart for processing a read chart image.

[0116] The chart **17** shown in **FIG. 15** has alternations of a black line having width of 1 dot and a white line having width of not less than 2 dots. It is of course possible to use a chart having one-dot-thick white lines and two-dot-thick black lines.

[0117] Referring to the flow charts of **FIGS. 16 and 17**, the operation of the second embodiment is described below in detail. However, Steps **S2-1** to **S2-4** are omitted from the description since they are the same as Steps **S1-1** to **S1-4** of the first embodiment.

[0118] After Step **S2-4**, steps **A1-1** to **A1-4** of **FIG. 17** are performed to obtain an output of an analysis result. At Step **A1-1**, a portion having the same values appeared not more than twice is detected among the integration results of Step **S2-4** (**FIG. 16**). The portion is recognized as a white line (of

not less than two-dots in width) of the analysis chart **17**. This can be easily understood from **FIG. 18**.

[**0119**] At Step **A1-2**, a value ahead by two dots from the recognized portion (i.e., a value just before a series of two same values) is subtracted from the value of the recognized portion and an obtained difference is recorded as an analysis value of the recognized position.

[**0120**] If the same values did not appear twice in series (at Step **A1-1**), the Step **A1-3** determines an analysis value of this position to be zero. This operation brings the analysis result as shown in **FIG. 19**. The comparison of **FIG. 19** with **FIG. 11** clearly shows that the use of the chart **17** of **FIG. 15** can also extract components of the scanning speed fluctuation.

[**0121**] Thus, the second embodiment achieves the analysis of scanning speed fluctuation of the image reading means.

[**0122**] [Third Embodiment of the Present Invention]

[**0123**] The third embodiment uses the same analysis chart **17** as used in the second embodiment.

[**0124**] The operation of this embodiment will be described below according the flow charts of **FIGS. 20 and 21**. However, Steps **S3-1** to **S3-4** are omitted from the description since they are the same as Steps **S2-1** to **S2-4** of the second embodiment. Namely, a subroutine **A2** to be performed between Steps **S3-2** and **S33** is explained as follows:

[**0125**] The subroutine **A2** consists of Steps **A2-1** to **A2-6**. Step **A2-1** detects positions of black lines on a read image of the chart by performing differential calculation with the output of Step **S3-2**. The resultant data represents an arrangement of discretely disposed blocks of white line portions since the initial chart image represents alternations of a black line and a white line. (The black line data exists between respective white blocks.)

[**0126**] Step **A2-2** extracts a portion having the second value of magnitude from the respective white-block data and stores it. If there are two equal peaks, the same value is stored. The operation result is shown in **FIG. 22**.

[**0127**] Step **A2-3** detects the least of the values of all blocks stored by Step **A2-2**. (The detected value is stored as a value "Wmin".) This means the detection of the least value other than zeros.

[**0128**] After this, the steps **A2-4** to **A2-6** of the subroutine are performed and then the processing of Step **S3-3** (**FIG. 20**) is executed to obtain the final analysis result (see **FIG. 24**).

[**0129**] [Fourth Embodiment of the Present Invention]

[**0130**] The operation of the fourth embodiment will be described below in detail according the flow charts of **FIGS. 25 and 26**. However, Steps **S4-1** to **S4-4** are omitted from the description since they are the same as Steps **S-1** to **S1-4** of the first embodiment.

[**0131**] A subroutine **A3** consists of Steps **A3-1** to **A3-5**. Step **A3-1** and **A3-2** are identical to Steps **A2-1** and **A2-3** respectively. So, they will not be further described.

[**0132**] While the third embodiment uses only the least of the values of shown in **FIG. 23** and multiplies every unprocessed data by the value, the fourth embodiment uses the value obtained at Step **A3-2** as a multiplier by which only unprocessed data on the periphery of the related white-line part is multiplied.

[**0133**] After the above processing, the flow chart is identical to the flow chart of the third embodiment (**FIG. 20**).

[**0134**] [Fifth Embodiment of the Present Invention]

[**0135**] The operation of the fifth embodiment will be described below according the flow charts of **FIG. 27**. Steps **S5-1**, **S5-2** are identical to Steps **S1-1**, **S1-2** respectively, Steps **S5-3**, **S5-5** are identical to Step **S1-3**, and Steps **S5-4**, **S5-6** are identical to Steps **S1-4**.

[**0136**] After Step **S5-2**, the same data is used for calculations by Step **S5-3** and a subroutine **A2**.

[**0137**] The flow chart after Step **S5-6** is similar to the subroutine **A1**. In this embodiment, when the same values are continuously detected at Step **S5-7**, Step **S5-8** stores the detected data position from the top of the image as a k-th position and Step **S5-10** executes the subtraction calculation of the data by using the k-th data prepared by Step **S5-4**.

[**0138**] [Sixth Embodiment of the Present Invention]

[**0139**] The operation of the sixth embodiment will be described below according the flow charts of **FIG. 28**. Steps **S6-1** and **S6-2** are identical to Steps **S1-1** and **S1-2**, Steps **6-3** and **S6-5** are identical to Steps **S1-3** and Steps **S6-4** and **S6-6** are identical to Step **1-4**.

[**0140**] After Step **S6-2**, the same data is used for calculations by Step **S6-3** and a subroutine **A3**.

[**0141**] The flow chart after Step **S6-6** is similar to the subroutine **A1**. In this embodiment, when the same values are continuously detected at Step **S6-7**, Step **S6-8** stores the detected data position from the top of the image as a k-th position and Step **S6-10** executes the subtraction calculation of the data by using the k-th data prepared by Step **S6-4**.

[**0142**] [Seventh Embodiment of the Present Invention]

[**0143**] The operation of the sixth embodiment will be described below according the flow charts of **FIG. 29**. Steps **S7-1** to **S7-3** are identical to Steps **S1-1** to **S1-3** respectively.

[**0144**] Step **S7-5** calculates an absolute value of the result obtained by Step **S7-3** and Step **S7-4** sets **1** for a positive result or **−1** for a negative result of the routine **A1** or judges the value to be positive or negative after holding the previous value when the result of the routine is 0. Step **S7-6** executes the multiplication of the result of Step **S7-4** by the result of Step **S7-5**.

[**0145**] [Eighth Embodiment of the Present Invention]

[**0146**] The flowchart of the eighth embodiment of the present invention is presented in **FIG. 30**. The flowchart before the subroutine **A2** is identical to that of the third embodiment and the flowchart after the subroutine is identical to that of the seventh embodiment. The description is therefore omitted.

[**0147**] [Ninth Embodiment of the Present Invention]

[**0148**] The flowchart of the ninth embodiment of the present invention is presented in **FIG. 31**. The flowchart before the subroutine **A3** is identical to that of the fourth

embodiment and the flowchart after the subroutine is identical to that of the seventh embodiment. The description is therefore omitted.

[0149] [Tenth Embodiment of the Present Invention]

[0150] The flowchart of the tenth embodiment of the present invention is presented in **FIG. 32**. This flowchart is similar to the flowchart of the eighth embodiment except Step **S10-8** at which the result of Step **S10-7** is multiplied by the data processed with a comb filter (Step **S10-3**) and subjected to calculation of absolute values (Step **S10-4**) instead of the data having passed through the subroutine **A2**.

[0151] [Eleventh Embodiment of the Present Invention]

[0152] The flowchart of the eleventh embodiment of the present invention is presented in **FIG. 33**. This flowchart is similar to the flowchart of the tenth embodiment excepting that the subroutine **A3** is used in place of the subroutine **A2**.

[0153] Other steps are similar to those of the tenth embodiment. Further description is therefore omitted.

[0154] The advantages of the present invention are as follows.

[0155] According to the present invention, it is possible to provide a document image reading device that can more stably read a document image by analyzing fluctuation of scanning speed of a scanner and controlling a driving motor of the device according to the result of analysis.

[0156] In other words, the device can separately extract components of the scanning speed fluctuation by reading variations of the optical density of respective reference scale lines, analyze the speed fluctuation state of its scanning means when scanning the image in the feed direction and eliminate the possibility of occurrence of image blur due to an unstable factor of the driving mechanism of the scanning means according to the analysis result.

[0157] A document-image reading device according to an aspect of the present invention can extract speed fluctuation based on variations of optical density of a speed fluctuation analyzing equal-pitch scale image read by an image reading means such as a line sensor, thus attaining higher resolution of analysis of the speed fluctuation as compared with a method of measuring spaces between lines of the equal-pitch scale image.

[0158] A document-image reading device according to another aspect of the present invention uses a measuring equal-pitch scale whose black (high-density) line or white (low-density) line has a width of two or more (integer) dots, thus eliminating the possibility of making the image data of the equal-pitch scale become an unanalysable 50% gray scale when the reading pitch cycle of the CCD in the feed direction deviates from the pitch cycle of the equal-pitch scale by a 1/2 dot.

[0159] In this device, the analysis result can be obtained by subtracting only peripheral portions when integrated values are the same subsequent values. This can avoid the affection of an abnormal value of the partial image on a whole analysis result, thus assuring the high accuracy of analysis.

[0160] A document-image reading device according to another aspect of the present invention can examine white (or black) levels of a whole image of an equal-pitch scale and compensate the whole image by using the same correction factor so that all the white (or black) portions may show a constant value. Therefore, the device can analyze the speed fluctuation of a scanner even when the white (or black) levels of the equal-pitch scale image cannot indicate a constant value due to insufficient adjustment of a signal processing system for an image reading section of the scanner.

[0161] The calculation amount can be saved since only one correcting value is used for correcting the white (or black) levels of the whole image.

[0162] The device can also examine the white (or black) levels of the equal-pitch scale image data and determine a specified correction value separately for each white (or black) portion so that the portion may have a preset constant value. This makes it possible to analyze the speed fluctuation without decreasing the analysis accuracy even if the white (or black) level of the scanner varies during the scanning.

[0163] In this case, the amount of calculation increases but the white level is real time measured and a correction value can be immediately determined with no need of waiting until the whole image data are measured. This enables designing a system capable of outputting the speed fluctuation analysis result just after reading the image.

[0164] A document-image reading device according to another aspect of the present invention uses corrected data only for determining the conditions of the speed fluctuation analysis and uses uncorrected data for determining speed fluctuation, then determines correction coefficients that make all white (or black) portions have a constant value. The device can therefore realize higher accuracy of the speed fluctuation analysis and less amount of calculation. The real time processing is also possible by determining correction factors for correcting respective white (or black) portions while the calculation amount increases.

[0165] A document-image reading device according to another aspect of the present invention calculates speed fluctuation by using absolute values of the resultant data obtained by processing the output of A/D converter with a comb filter.

[0166] Therefore, the finally obtained result of analysis may reflect each part changing from a white portion to a black portion and/or each part changing from a black portion to a white portion and, therefore, can attain increased accuracy.

[0167] The above-described processing may be conducted after correction for white (or black) shading with the same correction factor for all image-data, thus enabling the speed fluctuation analysis to be done even if the white levels of the equal-pitch scale did not meet a constant value due to insufficient adjustment of an image-reading signal-processing system of the scanner. Furthermore, the white (or black) level of the equal-pitch-scale image-data is corrected by using only one correction value for a whole image, thus achieving the saved amount of calculation.

[0168] The above-described processing may also be conducted after multiplying initial image data by corresponding correction factors separately determined for correcting respective white (or black) line portions to have a full bit

value (or a zero value). This enables the device to accurately analyze the speed fluctuation even if the shading level varies during scanning operation.

[0169] The device can also attain higher accuracy of analysis in the case when the image-reading section changes its state while reading an image.

[0170] A document-image reading device according to another aspect of the present invention uses corrected values for separating white portions from black portions and uses uncorrected data for calculating speed fluctuation, thus attaining increased accuracy of the speed fluctuation analysis.

[0171] The device can also determine correction factors for correcting respective white (or black) line portions to have a full bit value (or a zero value) output of an A/D converter and can separately correct the respective portions with corresponding correction factors, thus increasing the speed fluctuation analysis and, at the same time, assuring accurate analysis even if the shading level varies during the scanning operation.

1. A document-image reading device comprising a document image reading means for reading image data from a document at a specified time-interval based on a reference clock by moving said document image reading means or the document in a feed direction, wherein said document-image reading means is provided with a reference-chart reading means for reading a reference chart representing alternations of a high-density division and low-density division with the same width equal to a least readable pitch along a feed direction and image-data processing means for processing the image data read from the reference chart with a comb filter and by integration.

2. A document-image reading device comprising a document image reading means for reading image data from a document at a specified time-interval based on a reference clock by moving said document image reading means or the document in a feed direction, wherein said document-image reading means is provided with a reference-chart reading means for reading a reference chart representing alternations of a low-density or high-density division with a width equal to a least readable pitch and a high-density or low-density division with a width equal to an integer-multiple of the least readable pitch along the feed direction and an image-data processing means for processing the image data read from the reference chart by using a comb filter, performing integration calculations on the filtered data, extracting continuous detection of the substantially same integrated value by the integer-number of times and determining an integrated value at the extracted position by reducing the extracted integrated value by an integrated value of a upstream point along the feed direction at the distance of the integer-multiple of the least-readable pitch.

3. A document-image reading device comprising a document image reading means for reading image data from a document at a specified time-interval based on a reference clock by moving said document image reading means or the document in a feed direction, wherein said document-image reading means is provided with reference-chart reading means for reading a reference chart representing alternations of a low-density or high-density divisions with a width equal to a least readable pitch and a high-density or low-density division with a width equal to an integer-multiple of the least readable pitch along the feed direction and image-data processing means for separating the high-density divisions and low-density divisions from the read image-data, determining a correction factor by which image data for all low-density or high-density divisions or respective low-density or high-density divisions can be corrected to have a constant value, multiplying the image data by the correction factor, processing the image data read from the reference chart by using a comb filter, performing integral calculations on the filtered data, extracting continuous detection of the substantially same integrated value by the integer times and determining an integrated value at the extracted position by subtracting the integer-fold value of the least-readable pitch at the upstream side in the feed direction from the extracted integrated value.

4. A document-image reading device as defined in claim 3, wherein processing means is provided for determining a correction factor, multiplying image data by the correction factor, processing the corrected image data with a comb filter and by integration, detecting the substantially same values in series by the integer-number of times, reducing an integrated value, said value extracted from the uncorrected image data, by an integrated value of an upstream point in the feed direction at a distance of the integer-multiple of the least readable pitch and determining the reduced value as an integrated value of the extracted point.

5. A document-image reading device as defined in claim 2 or **3**, wherein storing means is provided for temporarily storing a result of processing an image data with a comb filter and by calculation of absolute values and the image-data processing means processes the image data with the comb filter followed by calculation of absolute values of the filtered data and temporarily store the processing result in the storing means, and, at the same time, conducts processing a read image of the reference chart with a comb filter and by integration, detects and extracts the substantially same values in series by the integer-multiple times, reducing an extracted integrated value by an integrated value at the upstream-side point in the feed direction at a distance of the integer-multiple of the least readable pitch, determines the reduced value as an integrated value of the extracted point, sets one for a positive resultant, zero for a zero resultant and −1 for a negative resultant, then multiplies each of the resultant values by the processed result temporarily stored in the storing means.

6. A document-image reading device as defined in claim 5, wherein absolute values used for multiplication processing are absolute values obtained by processing with the comb filter before correction of shading.

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