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(54) Product discrimination system and method therefor.

(57) A product discrimination system using a lens assembly for projecting an image of the product unit toward a randomized fiber optic cable. The end of the fiber optic cable is constructed in a rectangular section such that a long thin section of the product unit is viewed at any given time. The cable discharges the light at a lens and filter arrangement such that the emitted light may be divided into portions and filtered for measurement by photodiodes of specific and different wavelengths. Through a comparison of the wavelengths to a standard, attributes of the product unit can be determined.

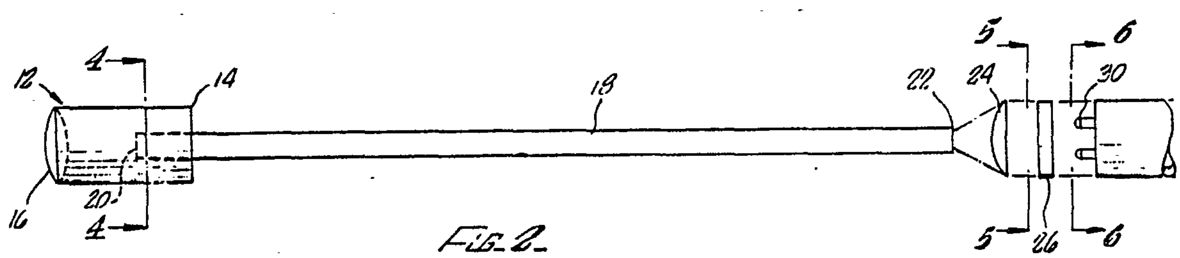

FIG. 2

EP 0 346 045 A2

PRODUCT DISCRIMINATION SYSTEM AND METHOD THEREFOR

BACKGROUND OF THE INVENTION

The field of the present invention is product discrimination systems based on color.

Fruit and vegetable products have been subject to sorting based on color in the past. Initially, such tasks were performed manually. More recently, as labor continues to be more and more expensive and unavailable, machine sorting by color has been attempted. A device capable of sorting by color is described in United States Patent No. 4,106,628 to Warkentin et al., the disclosure of which is incorporated herein by reference. In this system, color from a product unit is directed through lenses, fiber optics and filters to a sensing mechanism. Light from both sides of a product unit are equally mixed by a splitting and reforming of optic fibers used to transmit the light. In this way, an average from both sides of the product unit is achieved. The optic fibers are then split into two bundles. Filters of different wavelength capacity are employed to filter the light derived from the fiber optic bundles. Red and green filters are given as examples. The signals generated by the filtered light are then compared with a standard such that a red/green color classification may be made based on the readings compared with the standard.

More complicated sensing devices have been developed which use line scan cameras for determining such attributes as cross-sectional area. Such cameras have used light to present pixel information which may then be processed for summation and the like. In order to detect color using such a system, a very complicated system would be required because of the substantial amount of data to be received and processed. With product units traveling at any reasonable speed past such a discrimination system, it quickly becomes impossible to keep up with the processing of relevant information without a very substantial data processing system.

SUMMARY OF THE INVENTION

The present invention is directed to a product discrimination system employing the sensing of a variety of light spectra, which may include wavelengths both in and beyond the visible spectrum, from product units being classified. The magnitudes of the sensed light spectra may then be analyzed for determining such attributes of a product as size, ripeness, blemishes and color. According to the present invention, a manageable amount of data is received and processed by such a system with a maximum number of product factors being determined.

In a first aspect of the present invention, a focused image of a product unit is directed to a fiber optic array. The array has a first end which is arranged in a rectangle. Because of this arrangement, the fiber optic cable receives what approximates a line scan image. The image may be averaged and then divided and directed through filters to provide a plurality of sensed signals for different wavelengths. Intensity may be measured for each selected wavelength spectrum. Consequently, only a few signals, the magnitude of each separately filtered portion of the image, need be processed.

In another aspect of the present invention a method for discriminating attributes of product units is contemplated which uses absolute magnitudes and comparative relationships between the magnitudes of various spectra of light sensed from a product unit to determine such attributes as size, color, ripeness and blemishes.

Accordingly, it is an object of the present invention to provide improved apparatus and methods for the discrimination of product units by comparative analysis of a plurality of wavelength spectra of the product unit. Other and further objects and advantages will appear hereinafter.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a schematic illustration of a discrimination system of the present invention.

Figure 2 is a schematic illustration of an optical sensing device of the present invention.

Figure 3 is a schematic view of the viewing area of the device of Figure 2.

Figure 4 is a cross-sectional view taken along line 4-4 of Figure 2.

Figure 5 is a cross-sectional view taken along line 5-5 of Figure 2.

Figure 6 is a cross-sectional view taken along line 6-6 of Figure 2.

Figure 7 is a logic flow chart for analysis of the sensed light.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A product discrimination system is schematically illustrated in Figure 1. One or more objects 10, which are units of product to be sensed, are brought into appropriate position at a viewing station by a conveying means. Such a conveying means is illustrated in copending patent application Lyon & Lyon Docket 181/212 to Warkentin entitled Off-Loading Conveyor, the disclosure of which is incorporated herein by reference. The objects 10 may be illuminated as needed for appropriate sensing by conventional lights. Lens assemblies 12 are positioned to view and sense the electromagnetic energy, or light spectrum, from the objects 10. The lens assemblies 12 are positioned in accordance with the system design. It is possible to sense characteristics of each product unit passing through a station with one, two, three or more lens assemblies 12 directed at the station. With two such lens assemblies, as illustrated in Figure 1, a substantial portion of the object may be viewed. Additionally, the object may be rotated for sensing by the same elements or by additional elements further along the conveying path. Fiber optic cables 18 convey the sensed electromagnetic energy to a signal conditioning and processing unit. Depending on the capability of the processing unit, more than one station may be established on separate conveying paths with separate sets of lens assemblies.

Looking in greater detail to the optical sensing device, each lens assembly 12 includes a housing 14 with a lens 16 positioned at an aperture to the housing 14. The lens 16 is positioned at a specific distance from the path along which product units are to pass. With the single lens 16, a focal plane is thus defined within the housing 14. But for the aperture at which the lens 16 is located, the housing 14 is conveniently closed to prevent extraneous light from entering the housing and projecting on the focal plane.

Extending into the lens assembly 12 is a randomized fiber optic cable 18. Such a cable 18 is made up of a plurality of light transmitting fibers which are randomly bundled such that a pattern of light impinging on one end of the cable 18 will be mixed, or averaged, upon exiting the other end of the cable 18.

The cable 18 has a first end which is positioned at the focal plane of the lens 16. Further, the first end is arranged in a thin rectangular pattern in that focal plane. The pattern of this first end 20 is best illustrated in Figure 4. The arrangement of the first end 20 in a thin rectangular array at the focal plane of the lens 16 causes the image received by the cable 18 to be a thin rectangular area of the pathway through which product units travel. The image received by the cable 18 is, therefore, like that of a line scan camera. The length of the rectangle transverse to the direction of movement of the product unit is preferably greater than the largest dimension transverse to the conveying path of any an ticipated product unit. The width of the rectangular viewing area parallel to the direction of a movement is substantially smaller than the dimension along the conveying path of the anticipated product units. Given a constant speed of advancement of each product unit along the conveying path, the discrimination system can be configured such that sequential sensings are made as the product passes by the lens assemblies 12. A complete view of the product unit may be achieved by collecting sequential readings from the viewing area as the product moves across that viewing area.

The light energy received by the rectangular first end 20 of the cable 18 is transmitted along the cable to a second end 22. The second end 22 is conveniently circular in the present embodiment. The light transmitted through the cable is averaged and directed against a plano convex lens 24. The lens 24 is positioned such that the second end 22 lies at the focal point of the lens. Thus, the light passing through the lens from the second end 22 of the cable 18 is directed in a substantially nonconverging and nondiverging path. If the second end 22 of the cable 18 is in a circular shape, a similar yet magnified pattern will be transmitted by the lens 24.

Adjacent the lens 24 is a filter assembly 26. The filter assembly 26 may be positioned against or near the lens 24 to receive the light from the cable 18. The filter assembly 26 includes filter elements 28. The filter elements 28 are selected such that the separate elements filter different spectra of light. Thus, the filter assembly may include, for example, a red filter, a green filter, a yellow filter and even a filter outside of the visible spectrum. If the light from the lens 24 is arranged as discussed above, the filter assembly 26 is most conveniently circular with sectors of the circular assembly constituting the filter elements 28. Thus, from a rectangular image of a small slice of the product unit being viewed, a plurality of differently filtered light portions of the averaged light of the image are derived through the filter assembly 26. Four such equal portions are shown in the preferred embodiment. However, other arrangements could well be found beneficial for viewing particular product units.

To receive the divided and filtered portions of light from the original image, photodiodes 30 are presented adjacent the filter elements 28. In the preferred embodiment, one such diode 30 is associated with each filter element sector 28. Thus, an electronic signal is generated by each diode responsive to the magnitude of light conveyed through each of the filter elements.

The magnitude of each filtered portion may be compared against a standard stored in the data processing unit or converted by a factor or factors developed from prior comparisons with standard samples or tests. The accumulated segments or views making up an image formed by sequential images of the entire unit may also be processed in like manner. The standards within the processor or forming a basis for data conversion can be derived from sample product units having known physical attributes. Thus a pattern of magnitudes from the separate filtered portions or accumulation of portions for an entire unit can be compared with standards or converted for cross-sectional size, blemishes, ripeness and color. An indexing of the unit is also processed to fix the product unit on the conveying system. The processing unit may then time the diversion of each product unit according to its physical attribute or attributes to predetermined off-loading stations on the conveying system.

Figure 7 schematically illustrates analysis of the sensed light received by the photodiodes 30. Step 100 initiates the program. Step 102 initializes the sensed values, i.e., the product length and the magnitude of the light spectra separately sensed.

By step 102, the product length is set to zero. Product length is the length of the product in the direc tion of motion of the conveyor regardless of the product orientation. For example, what might normally be thought of as the product length may be lying crosswise to the conveyor and hence become its width as recognized by the system for purposes of discrimination. The length is measured in units of movement of the conveyor by a conventional indexing mechanism.

The summation of light magnitudes perceived by the photodiodes 30 is also set to zero. With multiple diodes 30, a plurality of light magnitudes are stored in separate sums. In the present example, four such magnitude summations are processed by the system.

Step 104 times the measurement of light magnitude to coincide with the presentation of a new unit length of product. This step is controlled by the indexing mechanism for the conveyor. By viewing sequential units or slices of the product as it passes through the station, a line scan process is approximated. However, the light received is averaged and individual units of the line scan, or pixels, do not exist. Thus, the useful attribute received is spectra magnitude.

Step 106 stores the magnitude of each light spectra sensed as the successive unit length passes through the viewing station. This storage of magnitude is controlled by step 104 such that an area which is one unit in length and the actual dimension of the product transverse to the direction of motion of the conveyor is sensed. The magnitudes of the selected light spectra are sensed by the photodiodes 30 and stored by this step.

Step 108 detects whether or not a product unit is present and whether or not the product unit just ceased to be present at the sensing station. If no product is sensed and no product was sensed in the just prior view, the no product logic path 110 is selected. Under this circumstance, logic step 102 is again initiated. If a product is sensed as being present, the product present logic path 112 is followed. If a product unit is not sensed but the just prior view did sense a product unit, the product end logic path 114 is followed.

In the product present logic path 112 when a product is sensed, the magnitude of each light spectra is added to any prior sum of such magnitudes in logic step 116. When the first sensing of a product unit passing through the viewing station occurs, the sum is zero from logic step 102. In successive views, each reading is added to the cumulative sum of magnitudes. The length is also summed in a similar manner with each sensed view being added to the prior length in step 118. Logic step 104 is then instituted to time the next reading.

The product end logic path 114 represents the conclusion of the sensing process on a product unit. In this path, the logic step 120 takes an average of the summed magnitude per unit length by dividing the summed magnitude by the length of the product unit. Other algorithms could be employed in this step. Such algorithms would depend on the unit being observed and the physical attribute or attributes to be employed for discrimination. Further, multiple algorithms could also be used where necessary. One such algorithm would be to pick the largest magnitude value of the units measured of a given product. Finally, logic step 122 allows the selection of an algorithm for calculating one or more of a plurality of physical attributes. Such attributes might include color, size of the product and product grade. In the case of size, the average color magnitude in association with the product length may give a sufficient approximation of cross-sectional area that the size or weight of the product unit might be determined. Under such circumstances, the readings might be used directly to provide discrimination or might be first converted into conventional units such as weight or volume through a comparison of the sensed values with a standard. Such a comparison might be undertaken with a constant factor, a table or other conventional means by which a standard is integrated into the interpretation of measured data. Once having resolved the nature of the product, the program is returned to initialize the summations of light spectra magnitude and length at zero.

The recognition of the physical attribute of the product may be result in a binary output or present specific magnitudes. In the case of a binary output, the product may be either retained or rejected at a given station through an on or. off signal to an actuator employed to remove products from a conveyor. As an example, heavily blemished product units or unusually large or small product units might be automatically off-loaded from the conveying system at an appropriate off-loading station. Further processing of sensed magnitudes on the other hand might be employed, for example, in selecting from a plurality of off-loading stations to achieve a specific load at each station. Through such a scheme, the estimated weight of individual units could be calculated and units selectively off-loaded at a at a plurality of stations to achieve a certain bag weight at each station. The signals generated by the system typically may actuate solenoid devices which in turn actuate off-loading systems. Naturally, the indexing mechanism associated with the conveyor is required to present input to the logic system such that the logic system can determine when a given product unit reaches an off-loading station and time the off-loading of the product unit.

Thus, a mechanism is contemplated for inputting light images of product units or portions thereof in an arrangement such that the output presents a plurality of measurable magnitudes of light in specified spectra useful for distinguishing between product units. While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art that modifications are possible without departing from the invention herein. The invention is not to be restricted except in the spirit of the appended claims.

Claims

1. A product discrimination system comprising a first lens;
a randomized fiber optic cable having a first end and a second end, said first end being rectangular and being positioned at the focal plane of said first lens for objects placed a predetermined distance from said first lens;
a plurality of photodiodes facing said second end;
a filter assembly including a plurality of filter elements each for filtering light spectra different from one another and each being positioned between said second end and a separate said photodiode.

2. The product discrimination system of claim 1 further comprising a second lens positioned between said second end and said filter assembly.

3. The product discrimination system of claim 2 wherein said second end is located at the focal point of said second lens.

4. The product discrimination system of claim 1 further comprising multiple said first lenses, randomized fiber optic cables, pluralities of photodiodes and filter assemblies, said first lenses being directed at a common point from angularly displaced positions.

5. A method for discriminating product units by physical attribute using light spectra, comprising the steps of
viewing a product unit including viewing sequentially in a first direction across the product unit thin rectangular segments each substantially narrower than the product unit in the first direction and at least as wide as the product unit in a second direction perpendicular to the first direction;
averaging the viewed light from each segment;
dividing the averaged light into portions;
filtering the portions of averaged light for spectra different from one another;
sensing the magnitude of each filtered portion.

6. The method of claim 5 further comprising the step of summing the magnitude of portions of like spectra from the segments ofthe product unit.

7. The method of claim 5 wherein said step of viewing a product unit includes viewing the product unit from two different directions.

8. The method of claim 5 wherein said step of dividing the viewed electromagnetic energy includes randomly mixing the viewed image with a randomized fiber optic cable and directing light from the cable to different filter elements.

9. The method of claim 5 further comprising the steps of
establishing a standard by performing the aforestated steps on products having known attributes to be measured and collecting the magnitudes of each filtered portion;
comparing the magnitudes sensed of the product unit with the standard.

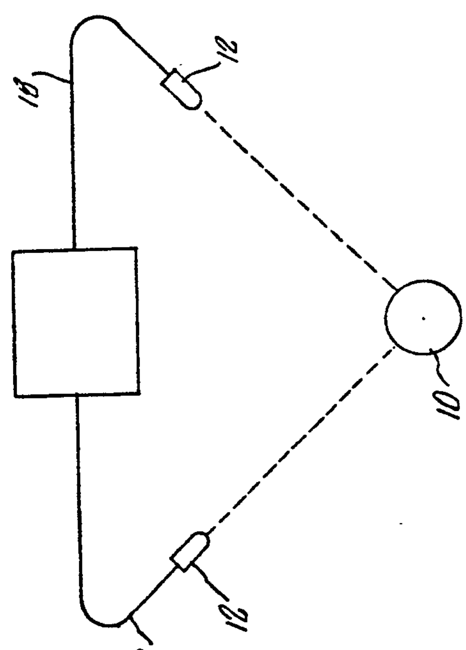

FIG. 1.

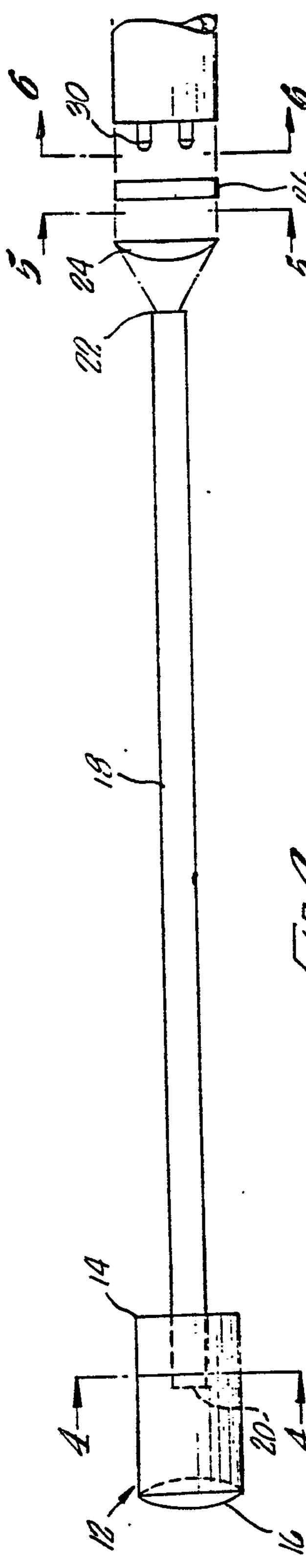

FIG. 2.

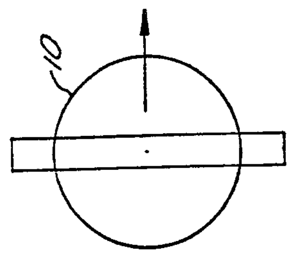

FIG. 3

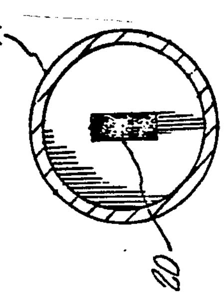

FIG. 4.

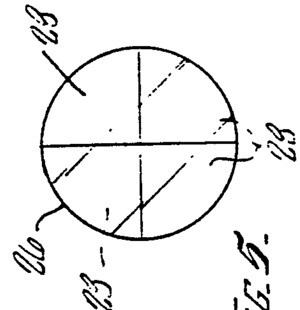

FIG. 5.

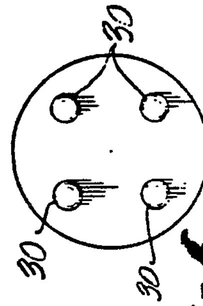

FIG. 6

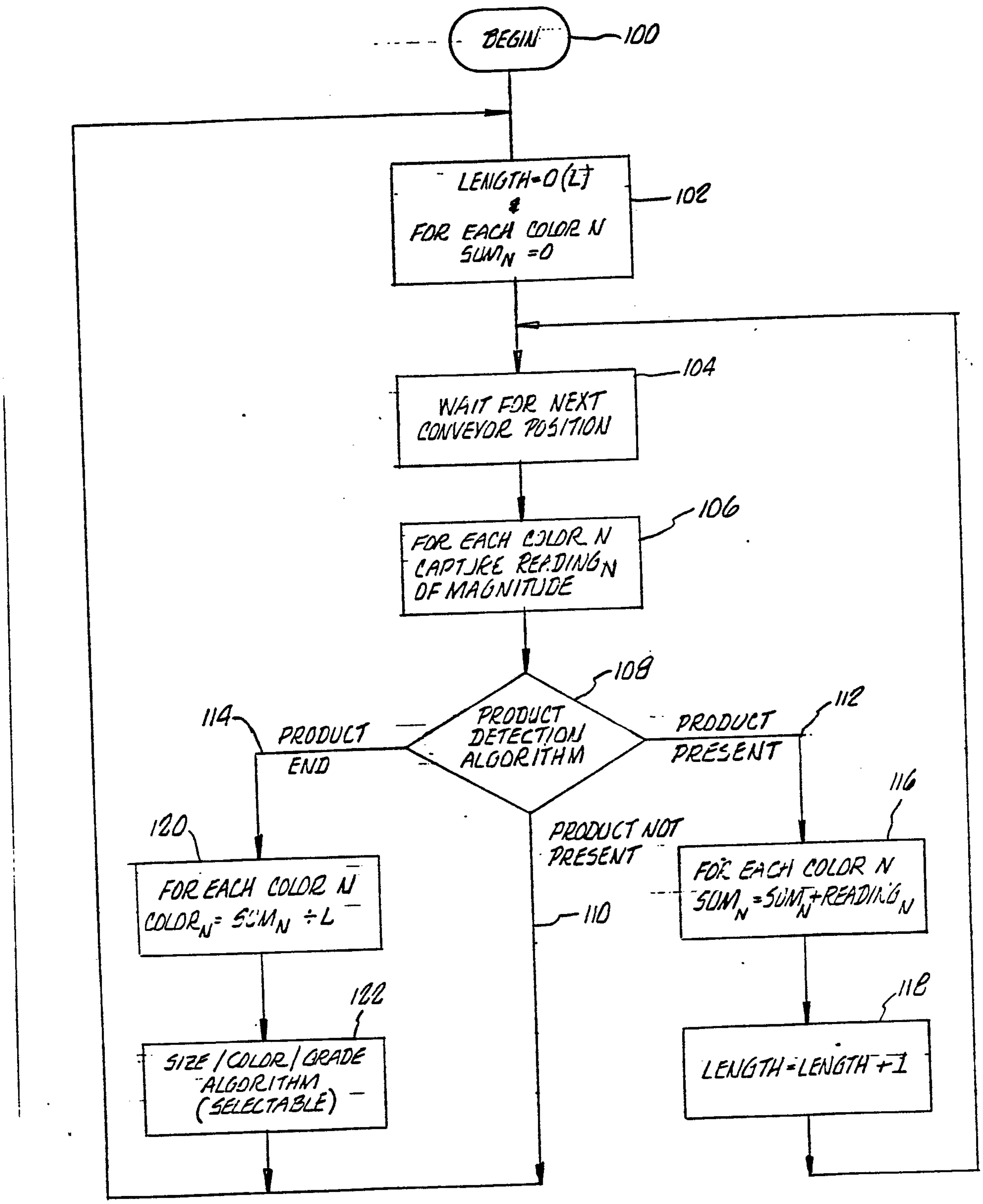
BEGIN
100
LENGTH=0 (L)
&
FOR EACH COLOR N
SUM_N = 0
102
WAIT FOR NEXT CONVEYOR POSITION
104
FOR EACH COLOR N CAPTURE READING_N OF MAGNITUDE
106
PRODUCT DETECTION ALGORITHM
108
PRODUCT END
114
PRODUCT PRESENT
112
PRODUCT NOT PRESENT
110
FOR EACH COLOR N
COLOR_N = SUM_N ÷ L
120
FOR EACH COLOR N
SUM_N = SUM_N + READING_N
116
SIZE / COLOR / GRADE ALGORITHM (SELECTABLE)
122
LENGTH = LENGTH + 1
118

FIG. 1