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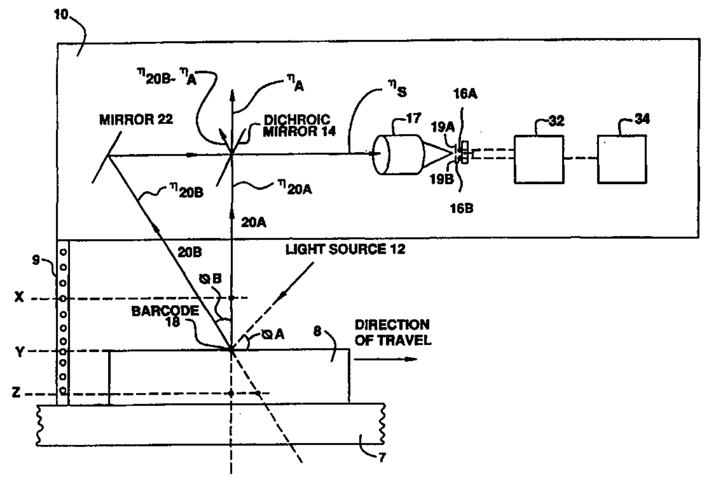

(57) Abstract

An optical scanner utilizes two linear CCD detectors and a bandpass means to improve the ability of the scanner to discriminate against specular reflection. A coded symbology is illuminated by a noncoherent light source and light reflected from the coded symbology along a first path strikes the front face of the bandpass means. The bandpass means, functioning as a notch filter, transmits a select bandwidth of light while reflecting all other light onto a first CCD detector. Simultaneously, light reflected from the bar code symbol travels along a second path, at a different angle with respect to the plane of the coded symbology than the first path, is reflected from a mirror onto the back face of the bandpass means. The bandpass means transmits the select bandwidth of light onto a second CCD detector and reflects all other light. The second CCD detector has a notch filter which permits the detection of only the select bandwidth. Since specular reflection is only experienced at a single angle, with respect to the plane of the coded symbology and each CCD detector detects an image at a different angle with respect to the plane of the coded symbology, a complete image can be reconstructed by combining information obtained from both CCD detectors.

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CCD SCANNER HAVING IMPROVED SPECULAR REFLECTION DISCRIMINATION

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to optical scanning systems. More particularly, this invention relates to a system and method capable of detecting coded symbologies in the presence of specular reflection.

Description of Related Art

Coded symbologies are being used in an increasingly diverse array of applications. The ability to track a large amount of items quickly and efficiently has led coded symbologies to be used in applications such as retail checkout, warehousing, inventory control and document tracking. As the volume of items tracked by coded symbologies has increased, the need for optical scanners which operate at high speeds has likewise increased.

Various optical scanning systems have been developed for reading and decoding coded symbologies. Scanning systems include optical laser scanners and optical charge-coupled device (CCD) scanners. Optical laser scanners generally employ a laser diode, a multifaceted polygonal mirror, focusing optics and a detector. The scanning rate of an optical laser scanner is limited by the number of facets on the mirror and the available motor speed.

CCD scanners may incorporate a non-laser light source and a CCD light detecting means, such as a CCD linear sensor. A portion of the light which is reflected from the coded symbology is detected by the CCD linear sensor and converted into an electrical signal which is the basis for a digital image of the coded symbology that has been scanned. The digital image is then processed and decoded according to the specific type of coded symbology.

One disadvantage with current CCD scanners is that they are susceptible to specular reflection which saturates areas of the CCD linear sensor and prohibits the detection of a portion of the optically coded information. This is particularly a problem when the coded symbology is printed under a highly reflective surface, such as a plastic coating.

Specular reflection is only a problem at a single angle, known as the "critical angle", between the light source, the reflective surface and the CCD linear sensor. Current methods of coping with specular reflection include placing separate scanners at different angles with respect to the surface. However, providing duplicate CCD scanners for this purpose is extremely expensive. Techniques involving light polarizers have also been used. However, due to the light losses introduced by the materials used to make light polarizers, they are extremely inefficient.

Accordingly, there exists a need for an efficient and inexpensive scanning system with the speed of a CCD scanner that can accurately read and decode coded symbologies in the presence of specular reflection.

SUMMARY OF THE INVENTION

The present invention utilizes two CCD linear sensors and a bandpass means to improve the ability of an optical scanner to discriminate against specular reflection. A coded symbology is illuminated by a noncoherent light source and light reflected from the coded symbology travels along a first path and strikes the front face of the bandpass means. The bandpass means, functioning as a notch filter, transmits a select bandwidth of light while reflecting all other light onto a first CCD linear sensor. Simultaneously, light reflected from the bar code symbol travels along a second path, at a different angle with respect to the plane of the coded symbology than the first path, and is reflected from a mirror onto the back face of the bandpass means. The bandpass means transmits the select bandwidth of light onto a second CCD linear sensor and reflects all other light. The CCD linear sensors each have a notch filter which permits the detection of only a select bandwidth. Since specular reflection is only experienced at a single angle with respect to the plane of the coded symbology, and each CCD linear sensor detects an image at a different angle with respect to the plane of the coded symbology; a complete image of the coded symbology is obtained by one or both of the CCD linear sensors, or can be reconstructed by combining information obtained from both CCD linear sensors.

Accordingly, it is an object of the invention to provide a CCD scanner which can read and decode coded symbologies in the presence of specular reflection.

Other objects and advantages will become apparent to those skilled in the art after reading the detailed description of a presently preferred embodiment.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a coded symbology scanning system made in accordance with the present invention;

Figure 2A is a diagram showing the spectrum of light;

Figure 2B is a more detailed diagram of the CCD detectors;

Figure 3 illustrates the method of using valid information from two views and selectively combining the information;

Figure 4 is a block diagram of the coded symbology logic unit;

Figure 5 is a flow diagram of the method of the present invention; and

Figure 6 is an alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment will be described with reference to the drawing figures wherein like numerals represent like elements throughout. Referring to **Figure 1**, a coded symbology scanning system **10** made in accordance with the present invention is shown. The coded symbology scanning system **10** is able to scan any type of coded symbology. However, for simplicity, reference hereinafter will be made to a particular type of coded symbology, i.e. a bar code symbol. The scanning system **10** includes a non-coherent light source **12**, a bandpass means **14**, a planar mirror **22**, focusing optics **17**, two CCD linear sensors **16A** and **16B**, two filters **19A** and **19B**, a logic unit **32** and an output means **34**.

The light source **12** facilitates detection of a subject bar code symbol **18** by illuminating the bar code symbol **18** located on a package **8** or other object. Preferably, the package **8** is supported by a moving conveyor belt **7**. The planar mirror **22** and the bandpass means **14** are aligned such that light reflected from the bar code symbol **18** along a first path **20A** strikes the front of the bandpass means **14**, while light traveling along a second path **20B** reflects off the planar mirror **22** and strikes the rear of the bandpass means **14**. It should be recognized by those skilled in the art that **Figure 1** is illustrative only and is not drawn to scale. For example, the angle θ_A between the light source **12** and the bar code symbol **18** is typically 77°. The angle θ_B between the first path **20A** and the second path **20B** is approximately 3-5°. However, it should be recognized by those skilled in the art that these angles are approximate and may vary widely depending upon the specific application and the mounting of the system **10** in relation to the bar code **18**.

The bandpass means **14** permits light of predetermined wavelengths around λ_A, striking either its front or rear surface, to pass through the mirror **14**, and reflects the remainder of the light spectrum. The spectrum of light λ_{20A} traveling along the first path **20A** strikes the front of the bandpass means **14**. Light having wavelengths around λ_A passes through the bandpass means **14**, while the remainder of the spectrum of light $\lambda_{20A}-\lambda_A\pm$ is reflected toward the CCD detectors **16A, 16B**. The spectrum of light λ_{20B} traveling along the second path **20B** is reflected off the planar mirror **22** and strikes the back of the bandpass means **14**. Light having wavelengths around λ_A passes through the bandpass means **14** toward the CCD detectors **16A**, **16B**, while the remainder of the light spectrum $\lambda_{20B}-\lambda_A\pm$ is reflected off the back of the bandpass means **14**. It should be appreciated that the bandpass means **14** may function as a filter wherein the bandpass means **14** transmits a small bandwidth of light while reflecting the remainder of the light spectrum. Alternatively, the bandpass means **14** may function as a mirror, wherein the bandpass means **14** reflects a small bandwidth of light while transmitting the remainder of the light spectrum. Preferably a mirrored dichroic filter is used.

The composite spectrum λ_S of light which reaches the focusing optics **17** comprises predetermined wavelengths around λ_A from the second path **20B** and the remainder of the spectrum $\lambda_{20A}-\lambda_A\pm$ from the first path **20A**. The composite spectrum λ_S passes through the focusing optics **17**, through the filters **19A**, **19B** and onto the CCD linear array detectors **16A**, **16B**. Both filters **19A, 19B** permit the respective detector **16A**, **16B** to detect non-overlapping bands of light.

Referring to **Figure 2**, the second CCD detector **16B** is filtered to detect light having wavelengths around λ_A. The first CCD detector **16A** is filtered to permit the detection of light around a different wavelength λ_B. For example, the bandpass means **14** may be calibrated to transmit light around wavelength λ_A of 650NM±. The second CCD detector **16B** is filtered to detect light around the wavelength λ_A of 650NM± originating from the second path **20B**. The first CCD detector **16B** is filtered to detect light around wavelength λ_B which originates from first path **20A**, for example 600NM±. Accordingly, the detectors **16A**, **16B** will detect two separate images of the bar code symbol **18**.

Although the detectors **16A, 16B** have been referred to as separate CCD linear sensors, preferably they comprise two of the three channels commonly found in a color CCD line scan sensor. In this embodiment, the color filters are preferably replaced with the appropriate notch filters **19A**, **19B**. Those of skill in the art should realize that the bandwidth transmitted by each notch filter **19A**, **19B**, including tolerances, should not overlap with the other notch filter **19A**, **19B**. Additionally, the notch filters **19A**, **19B** need not be of equal bandwidth. One notch filter **19A** may have a narrow bandwidth of 590-610NM±, and the other notch filter **19B** may have a wide bandwidth of 625-675NM±. Additionally, although two notch filters **19A**, **19B** may be employed, it is also possible to use one notch filter **19A**, wherein the other filter **19B** transmits all other wavelengths of light except for the bandwidth transmitted by the notch filter **19A**. In all of these examples, the tolerances of the filters **19A**, **19B** should be kept in mind to avoid any overlap. It should be apparent to those skilled in the art that the bandpass means **14** and the filters **19A**, **19B** over the CCD detectors **16A**, **16B** may be calibrated to detect any wavelength of light that is suitable for the desired application. The above values are illustrative only and should not be viewed as a limitation of the invention.

The light detected by the second CCD detector **16B** comprises light from the second path **20B** having wavelengths around λ_A. The light detected by the first CCD detector **16A** comprises light from the first path **20A** having wavelengths around λ_B. By definition, specular reflections only occur at a "critical angle". Once specular reflection occurs, this angle is defined and will be present only in one of the optical paths. Therefore, the other path will have useful information. If specular reflection "washes out" the view of the bar code symbol **18** at any point along the first path **20A**, specular reflection will not be present in the second path **20B** at the same point since the angle of the bar code symbol **18** with respect to the second path **20B** is different than the angle with respect to the first path **20A**.

Referring to **Figure 2B**, since the lengths of the two paths **20A**, **20B** are different, the detectors **16A**, **16B** must be selectively placed to account for this difference. In **Figure 1**, path **20A** is shorter than path **20B**. Preferably, the detectors **16A**, **16B** are mounted upon a common substrate which is rotated upon a center line **CL** to position the first detector **16A** further from the focusing optics **17** than the second detector **16B**.

Each of the CCD detectors **16A**, **16B** produces an electrical signal which corresponds to the detected light. Using the images **30A, 30B, 30C** in **Figure 3** as a visual example of the reconstruction process, comparison of images **30A** and **30B** shows that image **30A** has portions of specular reflection distortion, while image **30B** also has portions of specular reflection distortion. However, the non-distorted areas of the images **30A, 30B** can be used to form the complete image **30C**. Although the images **30A, 30B, 30C** are illustrated as area images, the preferred embodiment of the present invention detects and combines multiple line scans which make up the area images. It is clearly within the scope of the present invention to utilize detectors which detect either line or area scans.

Processing of the data from CCD detectors **16A**, **16B** to construct a complete bar code symbol **18** will be explained with reference to **Figure 4**. The data from the CCD detectors **16A**, **16B** is output and analyzed by the logic unit **32**. Depending upon the amount of specular reflection, data from one or both of the CCD detectors **16A**, **16B** may comprise a complete image of the bar code symbol **18**. In that case, the complete image is used for further decoding in accordance with the specific type of symbology. If specular reflection is detected by the logic unit **32** in the data output from the first CCD detector **16A** the logic unit **32** replaces the data with the data from the second CCD detector **16B**.

Referring to **Figure 4**, the logic unit **32** comprises two buffers **70A**, **70B**, a selector **72** and an arbitration unit **74**. The logic unit **32** receives the data, containing bar code information, from the CCD detectors **16A, 16B**. The information coming from the CCD detectors **16A, 16B** is selectively buffered depending upon the height of the package **8** upon which the bar code **18** is affixed. Referring back to **Figure 1**, at a first height **Y**, the information is obtained simultaneously from both light paths **20A, 20B**. Accordingly, no buffering of the data is required. However, when the package **8** to which the bar code **18** is affixed reaches height **X**, the second light path **20B** will obtain the bar code information prior to the first light path **20A**. Therefore, information from the second light path **20B** must be buffered by the buffer **70B** prior to comparison with the information from the first light path **20A**. Conversely, if the height of the package **8** to which the bar code **18** is affixed only reaches height **Z**, the first light path **20A** will detect the information prior to the second light path **20B**. In this event, the information from the first light path **20A** will be buffered by buffer **70A**. Each buffer **70A, 70B** delays the information obtained from the respective light path **20A, 20B** to synchronize the information with that obtained from the other light path **20B, 20A**. As discussed above, the delay is dependent upon the distance between the system **10** and the bar code symbol **18**. The distance between the system **10** and a package **8** having the bar code symbol **18** located thereon may be obtained by using a light curtain **9**, as in **Figure 1**, or by any other means which is well known by those skilled in the art. From the height, or distance, the delay value may be calculated, or a look up table may be used.

The delay value is then input into the desired buffer **70A, 70B**.

After the signal output from either detector **16A, 16B** has been buffered as necessary, the signals are compared by the arbitration unit **74**. The signals comprise values which represent the intensity of light detected by the pixels of the CCD detectors **16A**, **16B**. If the CCD detectors **16A**, **16B** have eight-bit resolution, the number of gray scale levels will be 255 (2^8-1). Depending upon the application, it may be assumed that a valid signal will have a gray scale value between 0 and 240. If the gray scale value exceeds a predetermined threshold of 240, specular reflection is present. This threshold may be adjusted depending upon the particular application. In the preferred embodiment the arbitration unit **74** controls the selector **72** to select the output from the second CCD detector **16B** when the value from the output from the first CCD detector **16A** exceeds 240. In this manner, a complete image of the bar code symbol **18** is obtained.

The logic unit **32** forwards a complete digital image, corresponding to the information encoded in the bar code symbol **18,** to an image processor **34** for decoding, storage or display, as is well known by those skilled in the art.

The scanning system **10** shown in **Figure 1** may be embodied in a mobile hand-held unit, or may be a stationary unit wherein an object carrying the bar code symbol **18** is passed under the light source **12** via a conveyor **7**.

In operation, the scanning system **10** executes the bar code symbol reading and decoding procedure **200** shown in **Figure**

4. The light source **12** illuminates a subject bar code symbol **18** (**step 210**). Light is reflected from the bar code symbol **18** along a first path **20A** toward the front of the bandpass means **14** (**step 220**). The bandpass means **14** transmits light around a first predetermined wavelength (**step 230**) and reflects the remainder of the light spectrum toward the CCD detectors **16A**, **16B** (**step 240**). The first CCD detector **16A** detects light around a second predetermined wavelength from the first light path **20A**. (**step 250**).

Simultaneously, light is reflected from the bar code symbol **18** along a second path **20B** (**step 270**) toward the back of the bandpass means **14** (**step 280**). The bandpass means **14** passes light around the first predetermined wavelength to the CCD detectors **16A**, **16B** (**step 290**) and reflects the remainder of the light spectrum away from the CCD detectors **16A**, **16B** (**step 300**). Light originating from the second path **20B** comprises only light around the first predetermined wavelength. Accordingly, it will be detected by the second CCD detector **16B** (**step 310**).

The CCD detectors **16A**, **16B** convert the detected light into electrical signals which are output to the logic unit **32** (**steps 260**, **320**). The logic unit **32** compares the signals (**step 330**) and the valid data is selected (**step 340**). This data is used to provide a complete bar code symbol **18**. In the event that both signals comprise non-distorted data, the non-distorted data of either signal may be used. The logic unit **32** then arbitrates the data representing the complete bar code symbol **18** (**step 350**) and forwards the data to the output means **34** (**step 350**).

Referring to **Figure 6**, an alternative embodiment of the scanning system **110** is shown in which additional mirrors **124** and **126** are added to the system **110** to direct the paths of light along a modified route. The modified route permits alignment of the components in cases where manufacturing or other considerations require that the components be placed in a configuration other than that shown in **Figure 1**. It should be understood that various additional components and configurations can be employed to alter the light paths and the intensity and precision of the light without departing from the spirit and scope of the invention.

Although the invention has been described in part by making detailed reference to the preferred embodiment, such detail is intended to be instructive rather than restrictive. It will be appreciated by those skilled in the art that many variations may be
made in the structure and mode of operation without departing from the teachings herein.

* * *

What is claimed is:

1. A scanner for scanning coded symbologies comprising:

a light source for illuminating a selected scan location;

means for detecting light reflected from an object located at said scan location at first and second angles of reflection; and

means for selecting between the light reflected at said first angle and light reflected at said second angle based on an evaluation of the intensity of the light being reflected at said first and second angles.

2. The scanner of claim 1 wherein said light detected at said first angle travels along a first path defined by a bandpass means; and light detected at said second angle travels along a second path defined by a mirror.

3. The scanner of claim 2 wherein said bandpass means comprises a filter and said second path includes said bandpass means.

4. The scanner of claim 3 wherein said bandpass means is a mirrored dichroic filter.

5. The scanner of claim 3 wherein said bandpass means comprises a notch filter; whereby said filter transmits only a portion of the bandwidth of the spectrum of light incident upon the filter.

6. The scanner of claim 5 wherein said detecting means further includes a first and a second light sensing means for detecting light at said first and second angles of reflection.

7. The scanner of claim 6 wherein said bandpass means transmits only a predetermined portion of the bandwidth of light incident upon it and reflects all other light; wherein said first light sensing means detects a portion of the spectrum of light from said first angle of reflection and said second light sensing means detects a portion of the spectrum of light from said second angle of reflection.

8. The scanner of claim 7 wherein said first light sensing means includes a first notch filter and said second light sensing means includes a second notch filter; wherein said first notch filter transmits a first predetermined bandwidth of light and said second notch filter transmits a second predetermined bandwidth of light.

9. The scanner of claim 8 wherein said first notch filter transmits light from said first path and said second notch filter transmits light from said second path.

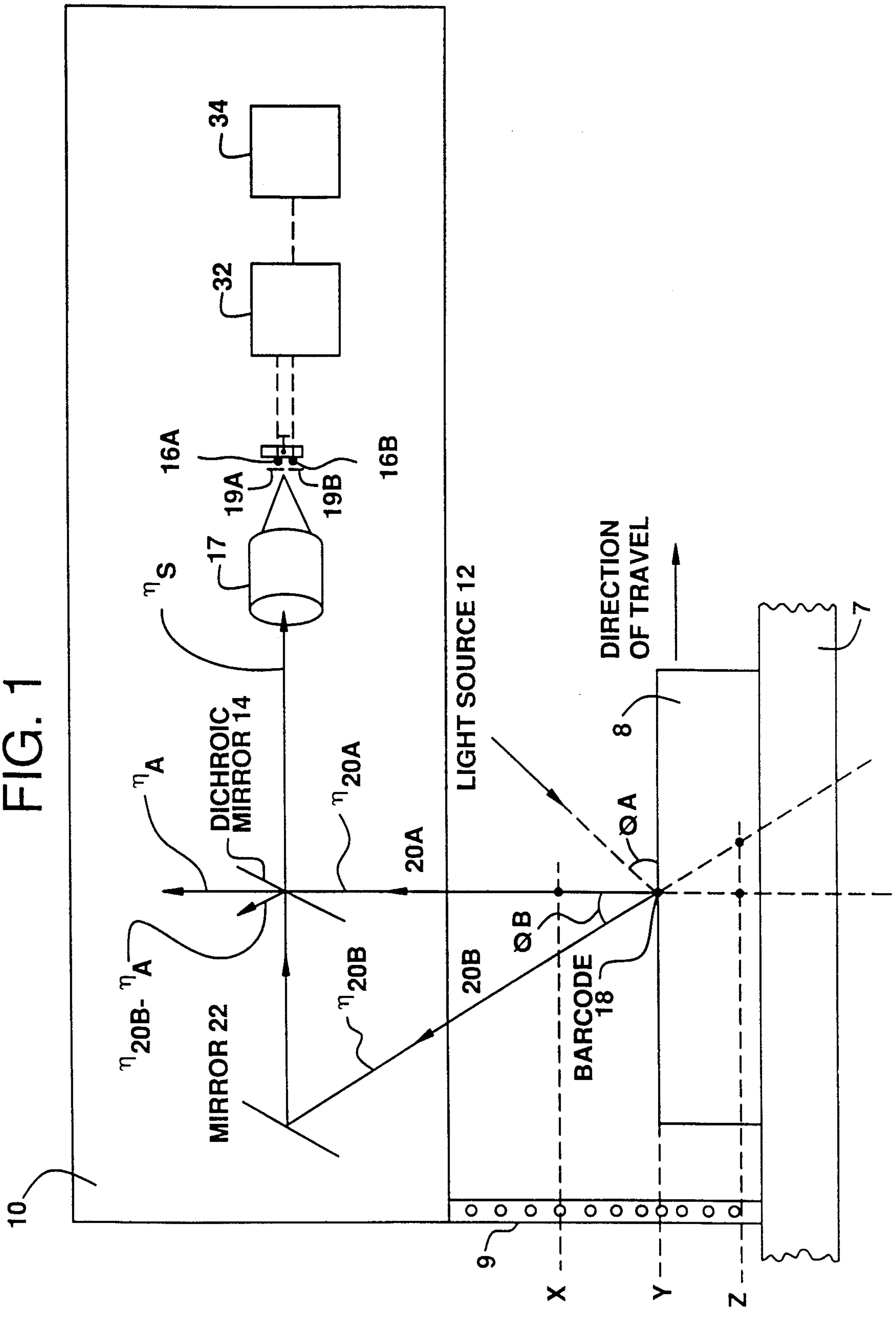
10. The scanner of claim 9 wherein both said first and second sensing means generate an electrical signal corresponding to the intensity of light incident thereupon.

11. A method for scanning coded symbologies comprising:

illuminating a selected scan location;

detecting light reflected from an object located at said scan location at first and second angles of reflection; and

selecting between the light reflected at said first angle and light reflected at said second angle based on an evaluation of the intensity of the light being reflected at said first and second angles.


34
32
16A
16B
19A
19B
17
η_S
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LIGHT SOURCE 12
7
8
DICHROIC MIRROR 14
η_A
η_{20A}
20A
ØA
ØB
$\eta_{20B}-\eta_A$
η_{20B}
20B
BARCODE 18
MIRROR 22
10
9
X
Y
Z

FIG. 1

FIG. 2A

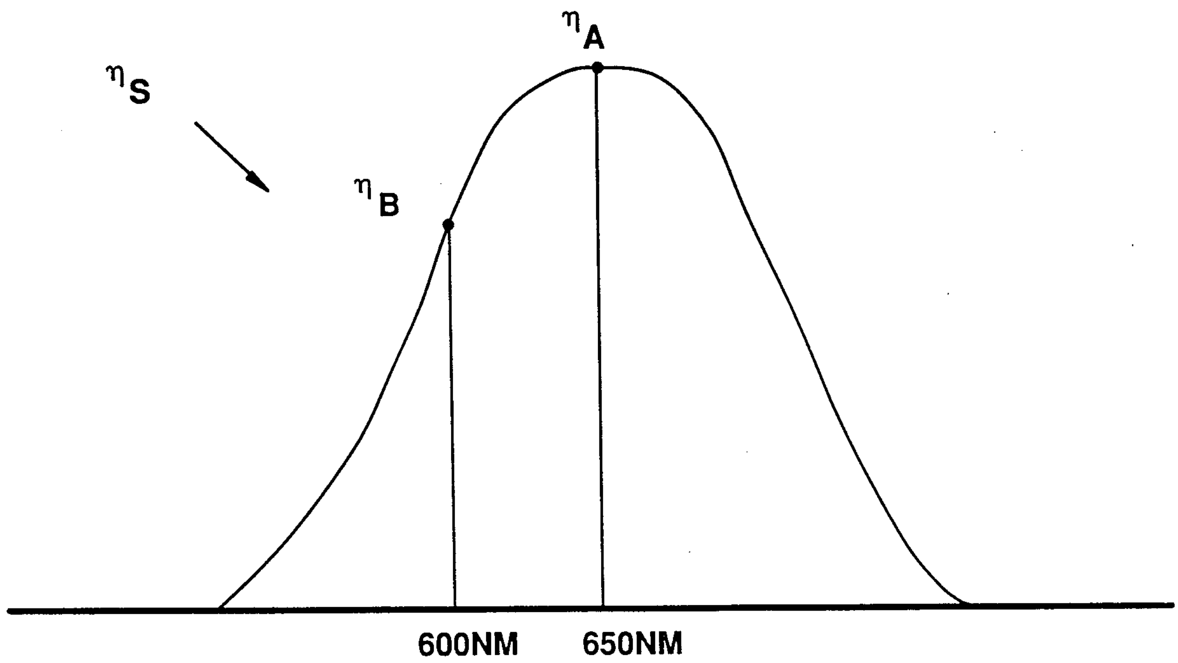


FIG. 2B

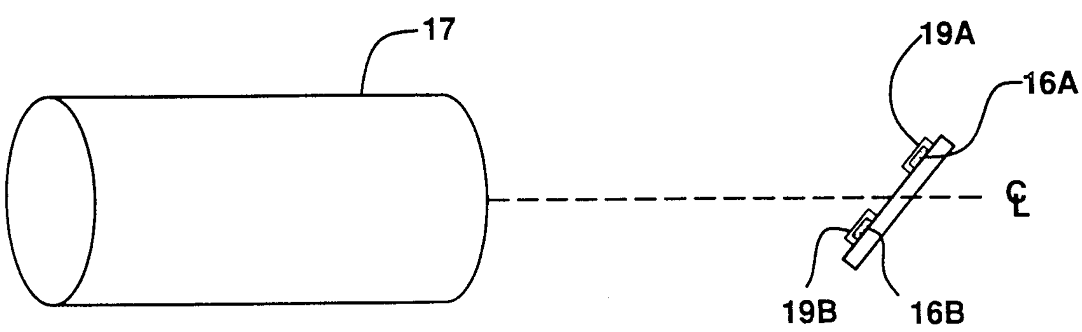


FIG. 3

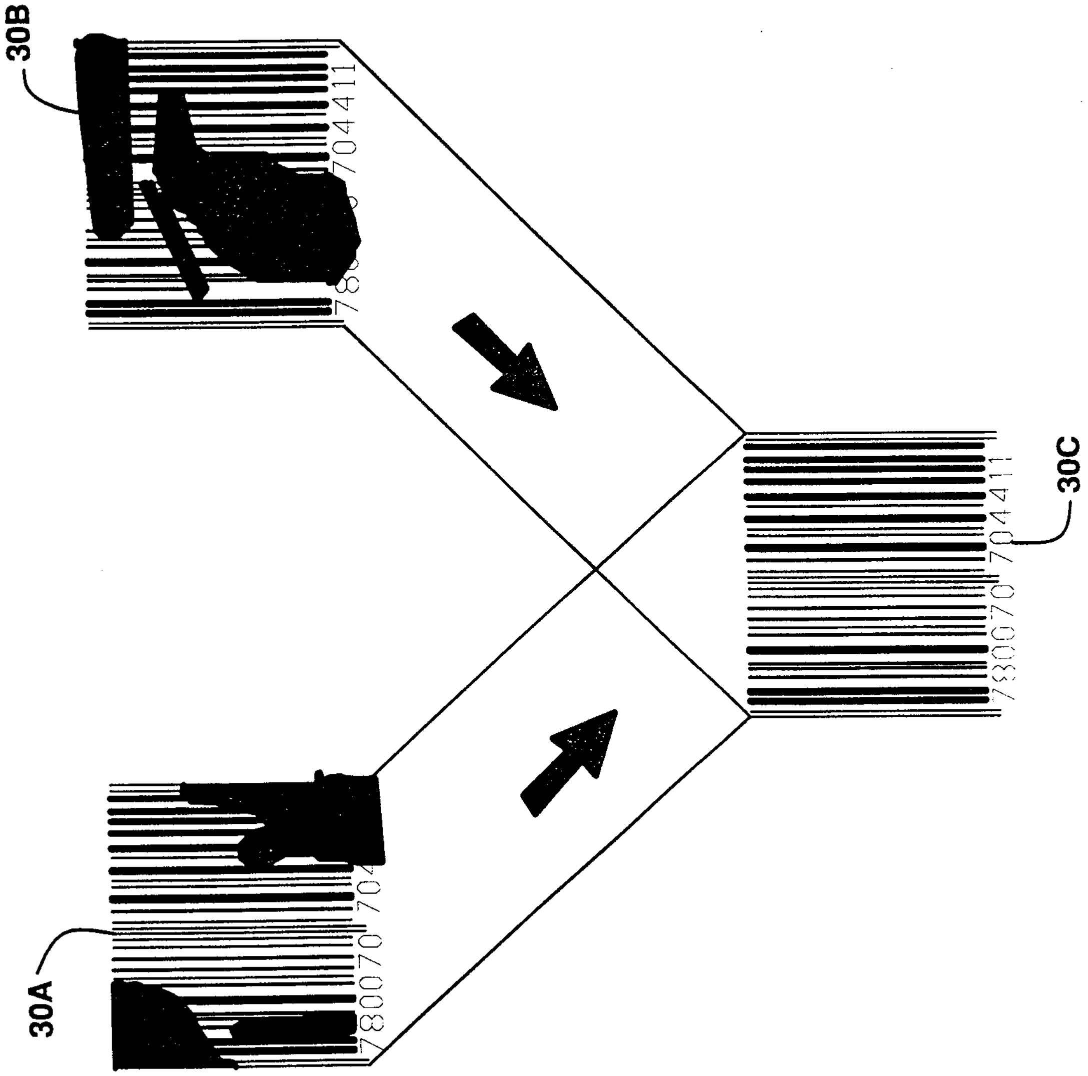
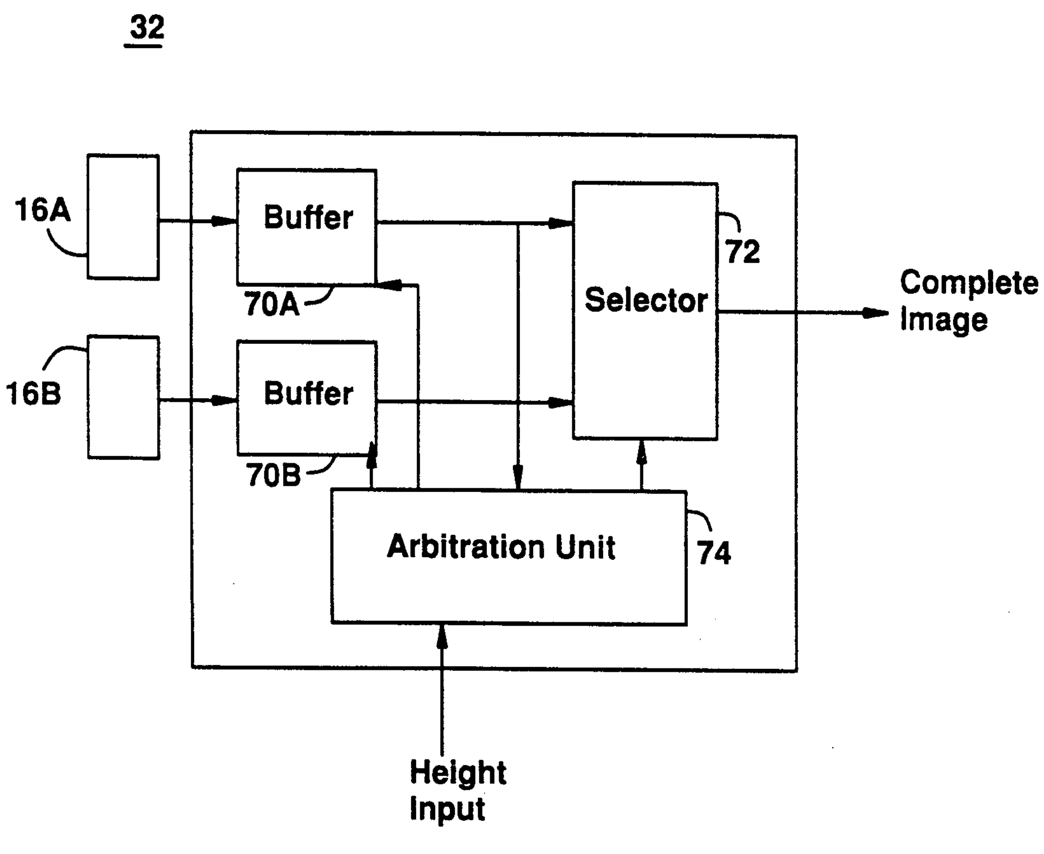


FIG. 4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16A
16B
Buffer
70A
Buffer
70B
Selector
72
Complete Image
Arbitration Unit
74
Height Input

FIG. 5

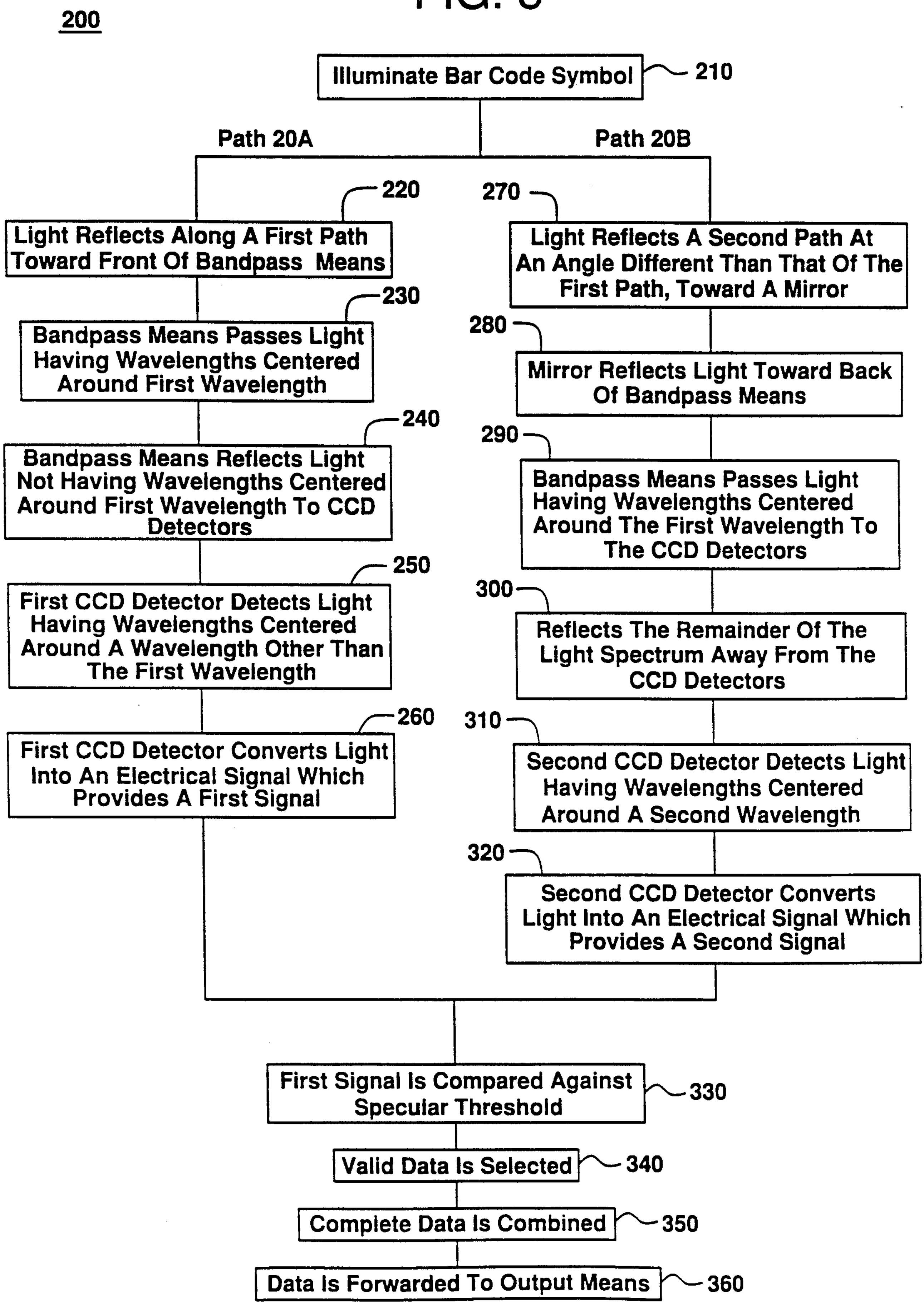
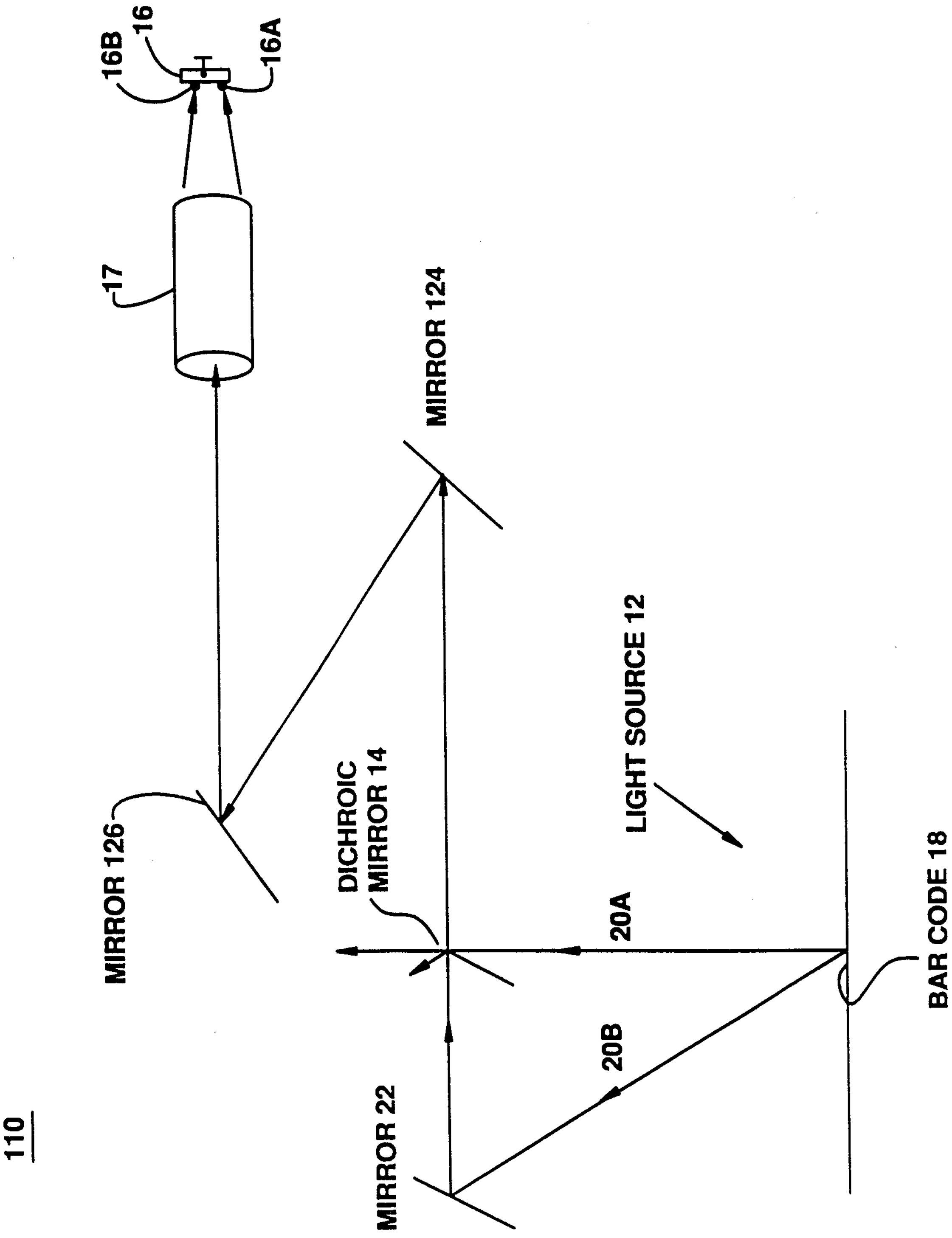

200
Illuminate Bar Code Symbol
210
Path 20A
Path 20B
220
Light Reflects Along A First Path Toward Front Of Bandpass Means
230
Bandpass Means Passes Light Having Wavelengths Centered Around First Wavelength
240
Bandpass Means Reflects Light Not Having Wavelengths Centered Around First Wavelength To CCD Detectors
250
First CCD Detector Detects Light Having Wavelengths Centered Around A Wavelength Other Than The First Wavelength
260
First CCD Detector Converts Light Into An Electrical Signal Which Provides A First Signal
270
Light Reflects A Second Path At An Angle Different Than That Of The First Path, Toward A Mirror
280
Mirror Reflects Light Toward Back Of Bandpass Means
290
Bandpass Means Passes Light Having Wavelengths Centered Around The First Wavelength To The CCD Detectors
300
Reflects The Remainder Of The Light Spectrum Away From The CCD Detectors
310
Second CCD Detector Detects Light Having Wavelengths Centered Around A Second Wavelength
320
Second CCD Detector Converts Light Into An Electrical Signal Which Provides A Second Signal
First Signal Is Compared Against Specular Threshold
330
Valid Data Is Selected
340
Complete Data Is Combined
350
Data Is Forwarded To Output Means
360

FIG. 6


110
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DICHROIC MIRROR 14
LIGHT SOURCE 12
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20B
BAR CODE 18
MIRROR 22

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B. FIELDS SEARCHED

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IPC 6 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 690 404 A (SYMBOL TECHNOLOGIES INC) 3 January 1996	1-3,11
A	see claims 4,13	5,10
X	EP 0 378 198 A (SUMITOMO ELECTRIC INDUSTRIES) 18 July 1990	1,11
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X	US 3 808 447 A (LEAVENS W) 30 April 1974 see claim 1	1,11

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 May 1998	04/06/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Herskovic, M

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/02302

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 011, no. 032 (P-541), 30 January 1987 & JP 61 201381 A (RICOH CO LTD), 6 September 1986, see abstract ---	1,11
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Information on patent family members

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