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[Continued on next page]

(54) **Title**: LASER SCANNING CODE SYMBOL READING SYSTEM PROVIDING CONTROL OVER LENGTH OF LASER SCAN LINE PROJECTED ONTO A SCANNED OBJECT USING DYNAMIC RANGE-DEPENDENT SCAN ANGLE CONTROL

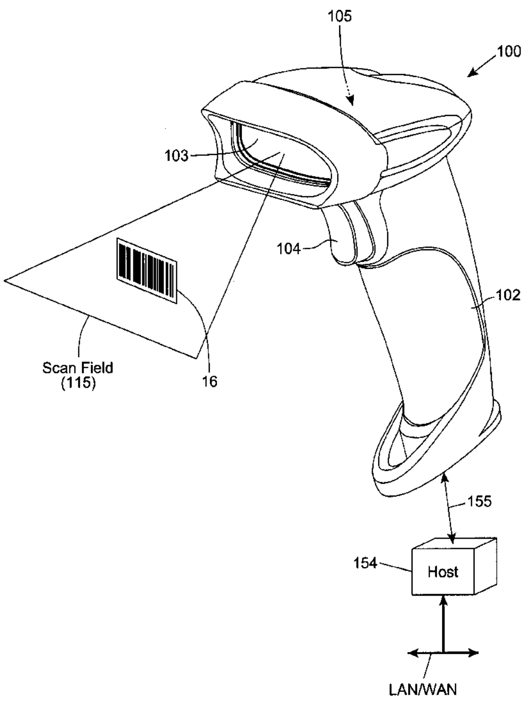

FIG. 1

(57) **Abstract**: Method of and system for reading bar code symbols using a hand-supportable laser scanning bar code symbol reading system supporting an improved level control over the length of laser scan lines projected onto scanned objects, at any instant in time, in a manner dependent the detected location, distance or range of the scanned object in the scanning field of the system during system operation. The length characteristics of the laser scan line are controlled by setting the laser scan sweep angle as a function of detected or estimated distance or range of the object from the system. In the illustrative embodiment, the laser scan sweep angle is controlled by supplying a drive current to the scanning mechanism, as a function of detected or estimated distance or range of the object from the scanning system.

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LASER SCANNING CODE SYMBOL READING SYSTEM PROVIDING CONTROL OVER THE LENGTH OF THE LASER SCAN LINE PROJECTED ONTO A SCANNED OBJECT USING DYNAMIC RANGE-DEPENDENT SCAN ANGLE CONTROL

BACKGROUND

Field of Disclosure

The present disclosure relates to an improved method of and apparatus for reading bar code symbols in diverse scanning environments using laser scanning beam technology.

Brief Overview of the State of The Art

It is well known that the depth of field (DOF) of a laser scanning system is limited by the bandwidth and amplitude of the electrical scan data signal generated while scanning a laser beam across a code symbol located at a distance from the scanning.

For example, in a fixed scan speed/sweep scanning system, if the laser beam scans an object located a long distance from the scanning system, then the velocity of the laser beam across the object will be very high. Consequently, the signal amplitude received at the scanning system will be relative weak (because of the long distance traveled), and the signal frequency bandwidth will be very high due to the high velocity of the laser beam across the code structure.

Also, in a fixed scan speed/sweep scanning system, if the laser beam scans an object located a short distance from the scanning system, then the velocity of the laser beam across the object will be lower than when scanning long distance objects. Consequently, the signal amplitude received at the scanning system will be relative strong (because of the short distance traveled), and the signal frequency bandwidth will be relatively lower due to the low velocity of the laser beam across the code structure.

Such laser scanning performance characteristics of conventional fixed scanning systems create additional signal processing bandwidth requirements within the analog signal processing stage of conventional laser scanning systems. In turn, this complicates the design and increases the cost of such conventional laser scanning systems.

There is a great need in the art to provide a novel laser scanning code symbol reading system and method supporting an improved level control over the length of laser scan lines projected onto scanned objects, while maintaining the return signal bandwidth relatively constant during scanning operations, and avoiding the shortcomings and drawbacks of prior art methodologies and apparatus.

OBJECTS OF PRESENT DISCLOSURE

A primary object of the present disclosure is to provide a hand-supportable laser scanning code symbol reading system supporting an improved level of control over the length of a laser scan line in the scanning field, without the shortcomings and drawbacks of prior art apparatus and methodologies.

Another object is to provide a laser scanning code symbol reading system supporting an improved level control over the length of laser scan lines projected onto scanned objects, while maintaining the return signal bandwidth relatively constant during scanning operations.

Another object is to provide such a laser scanning code symbol reading system, wherein the length characteristics of a laser scan line are controlled by setting the laser scan sweep angle as a function of detected or estimated distance or range of the object from the system.

Another object is to provide such a laser scanning code symbol reading system, wherein laser scan sweep angle is controlled by supplying a drive current to the scanning mechanism, as a function of detected or estimated distance or range of the object from the scanning system.

Another object is to provide a laser scanning bar code symbol reading system having the capacity to automatically control the length of a projected laser scan line from a laser source, at any instant in time, in a manner dependent the detected location, distance or range of the scanned object in the scanning field of the system during system operation.

Another object of the present disclosure is to provide a new and improved laser scanning code symbol reading system that automatically measures or estimates the distance or range between the laser scanning system and the scanned object, and then automatically adjusts the scan sweep angle of the laser scanning beam, as a function of object distance or range.

Another object is to provide a laser scanning code symbol reading system that offers better depth of field (DOF) performance in both the near-field (i.e. short distance) and far-field (i.e. long distance) portions of the laser scanning field.

Another object is to provide an improved method of laser scanning bar code symbols by detecting the location of the scanned object in the field of view of the system, and automatically controlling the length of a projected laser scan line from a laser source, at any instant in time, based on the detected scanning location.

Further objects of the present disclosure will become more apparently understood hereinafter and in the Claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to more fully understand the Objects, the following Detailed Description of the Illustrative Embodiments should be read in conjunction with the accompanying Drawings, wherein:

Fig. 1 is a perspective view of a first illustrative embodiment of a manually-triggered hand-supportable laser scanning bar code symbol reading system having the capacity to automatically control the length of a projected laser scan line at any instant in time, in a manner dependent on the determined/estimated range of the scanned object in the scanning field of the system during system operation;

Fig. 2 is a schematic block diagram describing the major system components of the manually-triggered laser scanning bar code symbol reading system illustrated in Fig. 1;

Fig. 3 is a schematic representation of a scan line data buffer maintained by the decode processor of the system of Fig. 1 during laser scanning operations, and holding a line of digital scan data for each laser scan direction during each laser scanning cycle;

Fig. 4 is a schematic representation of VLD in the laser scanning bar code symbol reading system of Fig. 1, generating and projecting three different laser scanning beams onto a object at three different scanning distances or ranges, so that a relatively constant length laser scan line is projected onto the object independent of scanning distance, by sweeping the laser beam through a different scan angle based on the object scanning distance;;

Fig. 5 sets forth a flow chart describing the primary steps carried out in the laser scanning bar code symbol reading system of Fig. 1, during each laser scanning object regardless of where the object is located within the scanning field of the system;

Fig. 6 is a perspective view of a second illustrative embodiment of an automatically-triggered hand-supportable dual-laser scanning bar code symbol reading system having the capacity to automatically control the length and intensity characteristics of a projected laser scan line from one of two laser sources, at any instant in time, in a manner dependent the detected location of the scanned object in the field of view of the system, during system operation;

Fig. 7 is a schematic block diagram describing the major system components of the automatically-triggered dual-laser scanning bar code symbol reading system illustrated in Fig. 6;

Fig. 8 is a schematic representation of a scan line data buffer maintained by the decode processor of the system of Fig. 6 during laser scanning operations, and holding a line of digital scan data for each laser scan direction during each laser scanning cycle;

Fig. 9 is a schematic representation the dual-VLDs in the laser scanning bar code symbol reading system of Fig. 6, generating and projecting three different laser scanning beams onto a object at three different scanning distances or ranges, so that a relatively constant length laser scan line is projected onto the object independent of scanning distance, by sweeping the laser beam through a different scan angle based on the object scanning distance; and

Figs. 10A and 10B set forth a flow chart describing the primary steps carried out in the automatically-triggered laser scanning system of Fig. 6, during each laser scanning object, regardless of where an object is located within the scanning field thereof.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

Referring to the figures in the accompanying Drawings, the illustrative embodiments of the dual laser-scanning bar code symbol reading system and will be described in great detail, wherein like elements will be indicated using like reference numerals.

Manually-Triggered Hand-Supportable Laser Scanning Code Symbol Reading System Employing Dynamically-Programmed Laser Scanning Angle Control

Referring now to Figs. 1 through 5, a first illustrative embodiment of a manually-triggered hand-supportable laser scanning bar code symbol reading system 1 will be described in detail.

As shown in Figs. 1 and 2, the manually-triggered laser scanning bar code symbol reader 100 has a working distance, and an assembly of components comprising: a hand-supportable housing 102 having a head portion and a handle portion supporting the head portion; a light transmission window 103 integrated with the head portion of the housing 102; a manually-actuated trigger switch 104 integrated with the handle portion of the housing, for generating a trigger event signal to activate laser scanning module 105 with laser scanning field 115; a laser scanning module 105, for repeatedly scanning, across the laser scanning field, a visible laser beam generated by a laser source 112 (e.g. VLD or IR LD) having optics to produce a laser scanning beam focused in the laser scanning field, in response to control signals generated by a system controller 150; wherein the laser scanning module 105 also includes a laser drive circuit 151 for receiving control signals from system controller 150, and in response thereto, generating and delivering laser (diode) drive current signals to the laser source 112A; a start of scan/end of scan (SOS/EOS) detector 109, for generating timing signals indicating the start of laser beam sweep, and the end of each laser beam sweep, and sending these SOS/EOS timing signals to the system controller 150, as well as decode processor 108; light collection optics 106 for collecting light reflected/scattered from scanned object in the scanning field, and a photo-detector for detecting the intensity of collected light and generating an analog scan data signal corresponding to said detected light intensity during scanning operations; an analog scan data signal processor/digitizer 107 for processing the analog scan data signals and converting the processed analog scan data signals into digital scan data signals, which are then converted into digital words representative of the relative width of the bars and spaces in the scanned code symbol structure and transmitted to decode processor 108 via lines 142; a scan data signal intensity detection module 141, preferably implemented within scan data processor/digitizer 107, for continuously (i) processing the return analog (or digital) scan data signals, (ii) detecting and analyzing the intensity (i.e. magnitude) of the laser return signal, (iii) determining (e.g. estimating) the range or distance of the scanned object, relative to the scanning window, and then (iv) transmitting the range indication (i.e. estimation) signal (e.g. in the form of a digital data value) to the controller 150 via lines 143 so that it can program or set an appropriate scan angle $\alpha(t)$ for the scanning assembly 110 to controlled by the scanner drive circuit 111 by the amplitude of the drive current supplied to the electromagnetic coil 128; a set of scan line data buffers 160 for buffering each complete line of scan data collected during a complete sweep of the laser scanning beam across the laser scanning field during each scanning cycle (e.g. two scan data line buffers for buffering data collected during scanning directions); programmed decode processor 108 for decode processing digitized data stored in said scan line data buffer 160, and generating symbol character data representative of each bar code symbol scanned by the laser scanning beam; an input/output (I/O) communication interface module 140 for interfacing with a host communication system 154 and transmitting symbol character data thereto via wired or wireless communication links 155 that are supported by the symbol reader and host system 154; and a system controller 150 for generating the necessary control signals for controlling operations within the hand-supportable laser scanning bar code symbol reading system.

As shown in Fig. 2, the laser scanning module 105 comprises a number of subcomponents, namely: laser scanning assembly 110 with an electromagnetic coil 128 and rotatable scanning element (e.g. mirror) 134 supporting a lightweight reflective element (e.g. mirror) 134A; a coil drive circuit 111 for generating an electrical drive signal to drive the electromagnetic coil 128 in the laser scanning assembly 110; and a laser beam source 112A for producing a visible laser beam 113A; and a beam deflecting mirror 114 for deflecting the laser beam 113A as incident beam 114A towards the mirror component of the laser scanning assembly 110, which sweeps the deflected laser beam 114B across the laser scanning field and a bar code symbol 16 that might be simultaneously present therein during system operation.

As shown in Fig. 2, the laser scanning module 105 is typically mounted on an optical bench, printed circuit (PC) board or other surface where the laser scanning assembly is also, and includes a coil support portion 110 for supporting the electromagnetic coil 128 (in the vicinity of the permanent magnet 135) and which is driven by a scanner drive circuit 111 so that it generates magnetic forces on opposite poles of the permanent magnet 135, during scanning assembly operation. Assuming the properties of the permanent magnet 135 are substantially constant, as well as the distance between the permanent magnet 135 and the electromagnetic coil 128, the force exerted on the permanent magnet 135 and its associated scanning element is a function of the electrical drive current $I_{DC}(t)$ supplied to the electromagnetic coil 128 during scanning operations. In general, the greater the level of drive current $I_{DC}(t)$ produced by scanner drive circuit 111, the greater the forces exerted on permanent magnet 135 and its associated scanning element, and in turn, the greater the resultant scan sweep angle $\alpha(t)$, and thus scan line length L_{SL} produced by the laser scanning beam. Thus, scan sweep angle $\alpha(t)$ of the scanning module 105 can be directly controlled by controlling the level of drive current $I_{DC}(t)$ supplied to the coil 128 by the scanner drive circuit 111 under the control of the scan drive current control module 150A, shown in Fig. 2. This will be the preferred method of controlling the scan sweep angle $\alpha(t)$ and scan line length L_{SL} in the present disclosure.

Preferably, the intensity detection module 141 is implemented within scan data processor/digitizer 107 which may be realized as an ASIC chip, supporting both analog and digital type circuits that carry out the functions and operations performed therein. The function of the intensity detection module 141 is manifold: (i) constantly process the return analog (or digital) scan data signals and detecting and analyzing the intensity (i.e. magnitude) of the laser return signal; (ii) determine (e.g. estimate) the range or distance of the scanned object, relative to the scanning window, during each measuring period; and (iii) transmit a range/distance indication signal (e.g. in the form of digital data value) to the system controller 150 for setting an appropriate scan sweep angle $\alpha(t)$ for the object to the scanned within the scanning field. Preferably, the range or distance of the scanned object can be determined (e.g. estimated), relative to the scanning window, during each measuring period, by making a relative signal-to-noise (SNR) measurement, where the lowest SNR value corresponds to the farthest possible scanning distance in the working range of the system (relative to the scanning window), and the highest SNR value corresponds to the shortest possible scanning distance in the working range of the system. Notably, module 141 may include tables storing pre-calibrated scanning range vs. SNR values which can be used in such range/distance determinations.

In general, system 100 supports a manually-triggered triggered mode of operation, and the bar code symbol reading method described below.

In response to the generation of a triggering event signal (i.e. by manually pulling trigger 104), the laser scanning module 105 generates and projects a laser scanning beam through the light transmission window 103, and across the laser scanning field external to the hand-supportable housing, for scanning an object in the scanning field. The laser scanning beam is generated by the laser beam source 112A in response control signals generated by the system controller 150. The scanning element (i.e. mechanism) 134 repeatedly scans the selected laser beam across a code symbol residing on an object in the laser scanning field 115, at the scan sweep angle set by the controller 150 for the current scanning cycle, determined by the process described in Fig. 3. Then, the light collection optics 106 collects light reflected/scattered from scanned code symbols on the object in the scanning field, and the photo-detector (106) automatically detects the intensity of collected light (i.e. photonic energy) and generates an analog scan data signal corresponding to the light intensity detected during scanning operations. The analog scan data signal processor/digitizer 107 processes the analog scan data signals and converts the processed analog scan data signals into digitized data signals. The programmed decode processor 108 decode processes digitized data signals, and generates symbol character data representative of each bar code symbol scanned by the laser scanning beam. The decoded bar code symbol could be a programming-type or menu-type bar code symbol, or an ordinary data-encoded bar code symbol not intended to perform or initiate any programming or special operations within the bar code symbol scanner.

Symbol character data, corresponding to the bar codes read (i.e. decoded) by the programmed decoder 108, is then transmitted to the host system 154 via the I/O communication interface 140, which may support either a wired and/or wireless communication link 155, well known in the art. During object detection and laser scanning operations, the system controller 150 generates the necessary control signals for controlling operations within the hand-supportable laser scanning bar code symbol reading system.

In general, system 100 supports a manually-triggered mode of operation, and a bar code symbol reading method described below.

In response to the manual actuation of trigger switch 104, the laser scanning module 105 generates and projects a laser scanning beam through the light transmission window 103, and across the laser scanning field 115 external to the hand-supportable housing, for scanning an object in the scanning field. The laser scanning beam is generated by the laser source 112B in response control signals generated by the system controller 150. The scanning element (i.e. mechanism) 134 repeatedly scans the laser beam across the object in the laser scanning field, at the scan sweep angle set by the controller 150 for the current scanning cycle, determined by the estimated/detected scanned object range, using the process described in Fig. 5. Then, the light collection optics 106 collects light reflected/scattered from scanned code symbols on the object in the scanning field, and the photo-detector (106) automatically detects the intensity of collected light (i.e. photonic energy) and generates an analog scan data signal corresponding to the light intensity detected during scanning operations. Within the analog scan data signal processor/digitizer 107, the intensity detection module 141 performs the following functions: (i) constantly processes the return analog (or digital) scan data signals; (ii) detects and analyzes the intensity (i.e. magnitude) of the laser return signal; (ii) determines (e.g. estimates) the range or distance of the scanned object, relative to the scanning window, during each measuring period; and (iv) transmits a range/distance indication signal (e.g. in the form of digital data values) to the controller 150 for setting an appropriate scan angle α(t) for the scanning assembly 110, based on the detected scanning distance.

The analog scan data signal processor/digitizer 107 also processes the analog scan data signal and converts the processed analog scan data signals into digitized data signals. The programmed decode processor 108 decode processes digitized data signals, and generates symbol character data representative of each bar code symbol scanned by the laser scanning beam. The decoded bar code symbol could be a programming-type or menu-type bar code symbol, or an ordinary data-encoded bar code symbol not intended to perform or initiate any programming or special operations within the bar code symbol scanner.

As indicated above, the scan angle α(t) of the laser scanning beam is determined by the range R(t) of the scanned object in the scan field, at any given moment in time. The range measure or estimate can be determined in at least two different ways: (i) by processing collected returned laser scan signals; or (ii) using range data produced by an LED or IR based object detection/range detection mechanism. In the case of processing return laser scanning signals, the laser light signal is converted to an electrical signal which is fed into module 141 in the analog scan data signal processor/digitizer 107. The strength of the processed analog or digital scan data signal, or the signal-to-noise ratio (SNR), is calculated and then used to estimate the distance/range of a scanned bar code symbol by the processor 107 which can be implemented an ASIC chip. A strong signal or a high ratio usually corresponds to a shorter range/distance, whereas a weak signal or low ratio corresponds to a larger range/distance. The scan angle α(t) of laser scanning beam can then be dynamically adjusted based on the signal strength or SNR, and a predetermined table/algorithm implemented in ASIC 107. Below is an exemplary table that is provided to illustrate the relationship among these three parameters, described above. The parameters can be tailored for scanners having different working ranges.

Signal strength or SNR determined as a % of the predetermined Maximum strength or SNR value	Distance/Range R(t) between Scanner and a scanned bar code symbol	Scanning Angle α(t) Selected as a % of the full Laser scan line
95%	2 inch	α_1 = _______ degrees ??
...	...	...
50%	1 foot	α_j = _______degrees ?

...	...	...
10%	2 feet	α_N = ________ degrees ?

Notably, the dynamically-defined scan sweep angle α(t) can be triggered under conditions which may differ during different scanning application. As the scan sweep angle α(t) is a function of object scanning range R(t), which can and typically will vary at any instant in time during scanning operations, it is understood that the duration of the dynamically-programmed scan angle will also change over time, and be dependent on the object range/distance determined by the analog scan data processor/digitizer 107, as described above.

Symbol character data, corresponding to the bar codes read (i.e. decoded) by the decoder 108, is then transmitted to the host system 154 via the I/O communication interface 140, which may support either a wired and/or wireless communication link 155, well known in the art. During object detection and laser scanning operations, the system controller 150 generates the necessary control signals for controlling operations within the hand-supportable laser scanning bar code symbol reading system.

Referring to Fig. 5, the method of reading bar code symbols and controlling operations within the laser scanning bar code reader 100 will be described in greater detail.

As indicated in Fig. 5, the process orchestrated by system controller 150 begins at the START Block, where all system components are activated except for the laser and scanning motor (i.e. electromagnetic coil). Then at Block B in Fig. 5, the system controller determines if a trigger or activation event has occurred (i.e. trigger switch 104 has been manually depressed by the operator).

In the event that a trigger event has been detected at Block B in Fig. 4, then the system controller proceeds to Block C1, and (i) activates the laser diode, and scanner drive circuit 111 with a sufficient current to generate a full default scan sweep angle $\alpha_o(t)$ and (ii) then starts timeout period timer T1.

At Block C2 in Fig. 4, the analog scan data signal processor/digitizer ASIC 107 processes the return analog and/or digital scan data signals, and automatically (i) measures (e.g. estimates) the range or distance between the scanned object and the scanner, (ii) determines the scan sweep angle α(t) as a function of determined object range/distance R(t), and (iii) programs the scan sweep angle α(t) for the given moment of time during the control process.

As indicated at Block D in Fig. 4, the system controller commands the buffering, in a scan data buffer 160, a complete line of scan data collected for scanning directions, over a full scan sweep angle set during the current scanning cycle. Scan data from each scan direction is buffered in a different scan line data buffer.

At Block E in Fig. 4, the system controller determines whether the decode processor 108 has decoded a bar code symbol based on the line of scan collected and buffered in the scan data buffer 160.

If, at Block E, a bar code symbol has not been decoded (i.e. read) within the buffered line of scan data, then the system controller proceeds to Block F and determines whether or not the time out period T1 has been reached. If the time out period has not been reached, then the system controller returns to Block C2, processes the scan data signals, determines the object range and updates the scan sweep angle $\alpha(t)$. Thereafter, the system controller proceeds to Block D and attempts to collect and decode scan data within time period T1 remaining. If the time out period has been reached, then the system controller proceeds to Block G, de-activates the laser source and scan motor, and then returns to Block B, as shown.

By virtue of the novel control process described in Fig. 4 the bar code symbol reader has the capacity to dynamically adjust the time a visible laser scanning beam is actively emitted from the VLD 112A as the object bearing a bar code symbol is being scanned at different scanning distances or ranges, so as to maintain the scan line length projected onto the scanned object within predetermined limits during the bar code symbol reading process.

In some applications, the scan line length L_{SL} can be maintained substantially constant on the scanned object regardless of the scanning distance R(t). In other embodiments, the scan line length L_{SL} on the scanned object may be maintained substantially constant within predetermined limits for different detected ranges of scanning distance R(t).

Automatically-Triggered Hand-Supportable Laser Scanning Bar Code Symbol Reading System Employing Dynamically-Programmed Laser Scanning Angle Control

Referring to Figs. 6 through 10B, a third illustrative embodiment of an automatically-triggered hand-supportable laser scanning bar code symbol reading system 500 will be described in detail.

As shown in Figs. 6 and 7, the automatically-triggered laser scanning bar code symbol reader 500 has a working distance, and an assembly of components comprising: a hand-supportable housing 102 having a head portion and a handle portion supporting the head portion; a light transmission window 103 integrated with the head portion of the housing 102; a IR-based (or LED-based) object detection and range subsystem 219 generating an IR or LED based light beam within the working range of the laser scanning field, as shown in Fig. 6, for automatically detecting the presence of an object in the laser scanning field, sending signals to the controller 150 so that the controller can trigger the system when an object is automatically detected in the scanning field and activate the near-field VLD 112A if the object is detected in the near-portion of the scanning field, or the far-field VLD 112B if the object is detected in the far-portion of the scanning field; a laser scanning module 105, for repeatedly scanning, across the laser scanning field, a visible laser beam generated by either (i) a first laser source 112A (e.g. VLD or IR LD) having near-field optics to produce a laser scanning beam 113A focused in the near-portion of the laser scanning field, or (ii) a second laser source 112B (e.g. VLD or IR LD) having far-field optics to produce a laser scanning beam 113B focused in the far-portion of the laser scanning field, in response to control signals generated by a system controller 150; wherein the laser scanning module 105 also includes a laser drive circuit 151 for receiving control signals from system controller 150, and in response thereto, generating and delivering different laser (diode) drive current signals to the laser source 112A, based on the detected or estimated distance or range of the scanned object in the scanning field; a start of scan/end of scan (SOS/EOS) detector 109, for generating timing signals indicating the start of laser beam sweep, and the end of each laser beam sweep, and sending these SOS/EOS timing signals to the system controller 150, as well as decode processor 108; light collection optics 106 for collecting light reflected/scattered from scanned object in the scanning field, and a photo-detector for detecting the intensity of collected light and generating an analog scan data signal corresponding to said detected light intensity during scanning operations; an analog scan data signal processor/digitizer 107 for processing the analog scan data signals and converting the processed analog scan data signals into digital scan data signals, which are then converted into digital words representative of the relative width of the bars and spaces in the scanned code symbol structure and transmitted to decode processor 108 via lines 142; a set of scan line data line buffers 160 for buffering each complete line of scan data collected during a complete sweep of the laser scanning beam across the laser scanning field during each scanning cycle (i.e. for both scanning directions); programmed decode processor 108 for decode processing digitized data stored in said scan line data buffer 160, and generating symbol character data representative of each bar code symbol scanned by the laser scanning beam; a scan data signal intensity detection module 141, preferably implemented within scan data processor/digitizer 10, for continuously (i) processing the return analog (or digital) scan data signals generated by photo-detector 106, (ii) detecting and analyzing the intensity (i.e. magnitude) of the laser return signal, (iii) determining (e.g. estimating) the range or distance of the scanned object, relative to the scanning window, and then (iv) transmitting the range indication (i.e. estimation) signal (e.g. in the form of a digital data value) via lines 143 to the controller 150 so that it can program or set an appropriate scan angle α(t) for the scanning assembly 110 to controlled by the scanner drive circuit 111 by the amplitude of the drive current supplied to the electromagnetic coil 128; an input/output (I/O) communication interface module 140 for interfacing with a host communication system 154 and transmitting symbol character data thereto via wired or wireless communication links 155 that are supported by the symbol reader and host system 154; and a system controller 150 for generating the necessary control signals for controlling operations within the hand-supportable laser scanning bar code symbol reading system.

Preferably, IR-based (or VLD-based) object detection subsystem 219 is mounted in the front of its light transmission window 103 so that its IR light transmitter and IR light receiver components (or VLD light transmitter and receiver components) of subsystem 219 have an unobstructed view of an object within the laser scanning field of the system, as shown in Fig. 1. Also, the object presence detection module 219 can transmit into the scanning field 115, IR (or visible) signals having a continuous low-intensity output level, or having a pulsed higher-intensity output level, which may be used under some conditions to increase the object detection range of the system. In alternative embodiments, the IR light transmitter and IR light receiver components can be realized as visible light (e.g. red light) transmitter and visible light (e.g. red light) receiver components, respectively, well known in the art. Typically the object detecting light beam will be modulated and synchronously detected, as taught in US Patent No. 5,340,971, incorporated herein by reference.

As shown in Fig. 7, the laser scanning module 105 comprises a number of subcomponents, namely: laser scanning assembly 110 with an electromagnetic coil 128 and rotatable scanning element (e.g. mirror) 134 supporting a lightweight reflective element (e.g. mirror) 134A; a coil drive circuit 111 for generating an electrical drive signal to drive the electromagnetic coil 128 in the laser scanning assembly 110; and a laser beam source (i.e. near-VLD) 112A for producing a visible laser beam 113A focused in the near-portion of the scanning field, and laser beam source (i.e. far-VLD) 112B for producing a visible laser beam 113B focused in the far-portion of the laser scanning field; and a beam deflecting mirror 114 for deflecting the laser beam 113A as incident beam 114A towards the mirror component of the laser scanning assembly 110, which sweeps the deflected laser beam 114B across the laser scanning field and a bar code symbol 16 that might be simultaneously present therein during system operation.

As shown in Fig. 7, the laser scanning module 105 is typically mounted on an optical bench, printed circuit (PC) board or other surface where the laser scanning assembly is also, and includes a coil support portion 110 for supporting the electromagnetic coil 128 (in the vicinity of the permanent magnet 135) and which is driven by a scanner drive circuit 111 so that it generates magnetic forces on opposite poles of the permanent magnet 135, causing mirror component 134 to oscillate about its axis of rotation, during scanning assembly operation. Assuming the properties of the permanent magnet 135 are substantially constant, as well as the distance between the permanent magnet 135 and the electromagnetic coil 128, the force exerted on the permanent magnet 135 and its associated scanning element is a function of the electrical drive current supplied to the electromagnetic coil 128 during scanning operations. In general, the greater the level of drive current $I_{DC}(t)$ produced by scanner drive circuit 111, the greater the forces exerted on permanent magnet 135 and its associated scanning element, and in turn, the greater the resultant scan sweep angle $\alpha(t)$, and thus scan line length L_{SL} produced by the laser scanning beam. Thus, scan sweep angle $\alpha(t)$ of the scanning module 105 can be directly controlled by controlling the level of drive current $I_{DC}(t)$ supplied to the electromagnetic coil 128 by the scanner drive circuit 111, under the control by scan drive current control module 150A, shown in Fig. 7. This will be the preferred method of controlling the scan sweep angle $\alpha(t)$ and scan line length L_{SL} in the present disclosure.

Preferably, the intensity detection module 141 is implemented within the scan data processor/digitizer 107 which may be realized as an ASIC chip, supporting both analog and digital type circuits that carry out the functions and operations performed therein. The function of the intensity detection module 141 is manifold: (i) constantly process the return analog (or digital) scan data signals and detecting and analyzing the intensity (i.e. magnitude) of the laser return signal; (ii) determine (e.g. estimate) the range or distance of the scanned object, relative to the scanning window, during each measuring period; and (iii) transmit a range/distance indication signal (e.g. in the form of digital data value) to the controller 150 for setting an appropriate scan sweep angle dependent of the measured, detected or estimated distance or range of the scanned object.

Preferably, the range or distance of the scanned object can be determined (e.g. estimated), relative to the scanning window, during each measuring period, by making a relative signal-to-noise (SNR) measurement, where the lowest SNR value corresponds to the farthest possible scanning distance in the working range of the system (relative to the scanning window), and the highest SNR value corresponds to the shortest possible scanning distance in the working range of the system.

Notably, module 141 may include tables storing pre-calibrated scanning range vs. SNR values which can be used in such range/distance determinations, R(t).

In general, system 500 supports an automatically-triggered mode of operation, and a method of bar code symbol reading as described below.

In response to the automatic detection of the object in the scanning field, the laser scanning module 105 generates and projects a laser scanning beam through the light transmission window 103, and across the laser scanning field 115 external to the hand-supportable housing, for scanning an object in the scanning field. Depending on where the object is detected within the scanning field, the laser scanning beam is generated by the laser source 112A or laser source 112B in response control signals generated by the system controller 150. The scanning element (i.e. mechanism) 134 repeatedly scans the laser beam 113A or 113B across the object in the laser scanning field, at the scan sweep angle set by the controller 150 for the current scanning cycle, determined by the estimated/detected scanned object range, using the process described below. Then, the light collection optics 106 collects light reflected/scattered from scanned code symbols on the object in the scanning field, and the photo-detector (106) automatically detects the intensity of collected light (i.e. photonic energy) and generates an analog scan data signal corresponding to the light intensity detected during scanning operations. Within the analog scan data signal processor/digitizer 107, the intensity detection module 141 performs the following functions: (i) constantly processes the return analog (or digital) scan data signals; (ii) detects and analyzes the intensity (i.e. magnitude) of the laser return signal; (ii) determines (e.g. estimates) the range or distance of the scanned object, relative to the scanning window, during each measuring period; and (iv) transmits a range/distance indication signal (e.g. in the form of digital data values) to the controller 150 for setting an appropriate scan angle $\alpha(t)$ for the scanning assembly 110, based on the detected scanning distance.

The analog scan data signal processor/digitizer 107 also processes the analog scan data signal and converts the processed analog scan data signals into digitized data signals. The programmed decode processor 108 decode processes digitized data signals, and generates symbol character data representative of each bar code symbol scanned by the laser scanning beam. The decoded bar code symbol could be a programming-type or menu-type bar code symbol, or an ordinary data-encoded bar code symbol not intended to perform or initiate any programming or special operations within the bar code symbol scanner.

As indicated above, the scan angle of the laser scanning beam is determined by the range R(t) of the scanned object in the scan field, at any given moment in time. The range measure or estimate R(t) can be determined in at least two different ways: (i) by processing collected returned laser scan signals; or (ii) using range data produced by an LED or IR based object detection/range detection mechanism. In the case of processing return laser scanning signals, the laser light signal is converted to an electrical signal which is fed into module 141 in the analog scan data signal processor/digitizer 107. The strength of the processed analog or digital scan data signal, or the signal-to-noise ratio (SNR), is calculated and then used to estimate the distance/range of a scanned bar code symbol by the processor 107 which can be implemented an ASIC (or FPGA) chip or other implementation technology. A strong signal or a high ratio usually corresponds to a shorter range/distance, whereas a weak signal or low ratio corresponds to a larger range/distance. The scan angle $\alpha(t)$ of laser scanning beam can then be dynamically adjusted based on the signal strength or SNR, and a predetermined table/algorithm implemented in ASIC 107. Below is an exemplary table that is provided to illustrate the relationship among these three parameters, described above. The parameters can be tailored for scanners having different working ranges.

Signal strength or SNR determined as a % of the predetermined Maximum strength or SNR value	Distance/Range R(t) between Scanner and a scanned bar code symbol	Scanning Angle $\alpha(t)$ Selected as a % of the full Laser scan line
95%	2 inch	α_1 = ______ degrees ??
...	...	...
50%	1 foot	α_j = ______ degrees ?
...	...	...
10%	2 feet	α_N = ______ degrees ?

Notably, the dynamically-defined scan sweep angle $\alpha(t)$ can be triggered under conditions which may differ during different scanning application. As the scan sweep angle $\alpha(t)$ is a function of object scanning range R(t), which can and typically will vary at any instant in time during scanning operations, it is understood that the duration of the dynamically-programmed scan angle will also change over time, and be dependent on the object range/distance determined by the analog scan data processor/digitizer 107, as described above.

Symbol character data, corresponding to the bar codes read (i.e. decoded) by the decoder 108, is then transmitted to the host system 154 via the I/O communication interface 140, which may support either a wired and/or wireless communication link 155, well known in the art. During object detection and laser scanning operations, the system controller 150 generates the necessary control signals for controlling operations within the hand-supportable laser scanning bar code symbol reading system.

Referring to Fig. 10A, the method of reading bar code symbols and controlling operations within the laser scanning bar code reader 50 will be described in greater detail.

As indicated in Fig. 10A, the process orchestrated by system controller 150 begins at the START Block, where all system components are activated except for the laser and scanning motor (i.e. electromagnetic coil). Then at Block A1 in Fig. 10A, the system controller determines if an object is detected in the scan field. In the event that an object has been detected at Block A1, then the system controller proceeds to Block A2, and determines whether the detected object has been detected in the near-portion of the scanning field. If so, then at Block B, the system controller (i) activates the laser diode, and scanner drive circuit 111 with a sufficient current to generate a default scan sweep angle $\alpha_o(t)$ for the near-portion of the scanning field, (ii) then starts timeout period timer T1, (iii) scans the object using the near-field VLD, (iv) collects and processes scan data to determine the range or distance of the scanned object from the scanning window, and (v) and then sets the scan angle for the measured or estimated range, and then collects and processes a line of scan data from the object at the detected range. The system controller commands buffering, in the scan data buffer 160, a complete line of scan data collected for scanning directions, over a full scan sweep angle set during the current scanning cycle. Scan data from each scan direction is buffered in a different scan line data buffer. At Block C, the decode processor runs a decode algorithm on the collected and buffered line of scan data.

At Block D, the system controller determines whether the decode processor 108 has decoded a bar code symbol based on the line of scan collected and buffered in the scan data buffer 160. If, at Block D, a bar code symbol has been decoded (i.e. read) within the buffered line of scan data, then at Block E, the system controller transmits symbol character data to the host system, and returns to Block A1. If, at Block D, a bar code symbol has not been decoded (i.e. read) within the buffered line of scan data, then at Block F1 the system controller determines whether or not the time out period T1 has been reached (i.e. maximum scan threshold has been reached or accomplished). If the time out period has not been reached, then the system controller returns to Block B, processes the scan data signals, determines the object range and updates the scan angle of the laser scanning beam, and attempts to collect and decode scan data within time period T1 remaining. If the time out period has been reached, then the system controller proceeds to Block F2, sends a failure to decode notification, and can de-activate the laser source and scan motor (if programmed to do so), and then returns to Block A1, as shown.

If at Block A2 in Fig. 10A, the detected object is not detected within the near-portion of the scanning field, then the system controller proceeds to Block G, and controller (i) (re)activates the laser diode, and scanner drive circuit 111 with a sufficient current to generate a default scan sweep angle $\alpha_o(t)$ for the far-portion of the scanning field, (ii) starts timeout period timer T1, (iii) scans the object using the far-field VLD, (iv) collects and processes scan data to determine the range or distance R(t) of the scanned object from the scanning window, and (v) and then sets the scan angle $\alpha(t)$ for the measured or estimated range, and then collects and processes a line of scan data from the object at the detected range. The system controller commands buffering, in the scan data buffer 160, a complete line of scan data collected for scanning directions, over a full scan sweep angle set during the current scanning cycle. Scan data from each scan direction is buffered in a different scan line data buffer. At Block H, the decode processor runs a decode algorithm on the collected and buffered line of scan data.

At Block I, the system controller determines whether the decode processor 108 has decoded a bar code symbol based on the line of scan collected and buffered in the scan data buffer 160. If, at Block I, a bar code symbol has been decoded (i.e. read) within the buffered line of scan data, then at Block J, the system controller transmits symbol character data to the host system, and returns to Block A1. If, at Block I, a bar code symbol has not been decoded (i.e. read) within the buffered line of scan data, then at Block K the system controller determines whether or not the time out period T1 has been reached (i.e. maximum scan threshold has been reached or accomplished). If the time out period has not been reached, then the system controller returns to Block G, processes the scan data signals, determines the object range and updates the scan angle of the laser scanning beam, and attempts to collect and decode scan data within time period T1 remaining. If the time out period has been reached, then the system controller proceeds to Block L, sends a failure to decode notification, and can de-activate the laser source and scan motor (if programmed to do so), and then returns to Block A1, as shown.

By virtue of the novel control process described in Figs. 10A and 10Bthe bar code symbol reader has the capacity to dynamically adjust the time a visible laser scanning beam is actively emitted from VLDs 112A or 112B as the object bearing a bar code symbol is being scanned at different scanning distances or ranges, so as to maintain the scan line length projected onto the scanned object within predetermined limits during the bar code symbol reading process. In some applications, the scan line length L_{SL} can be maintained substantially constant on the scanned object regardless of the scanning distance R(t). In other embodiments, the scan line length L_{SL} on the scanned object may be maintained substantially constant within predetermined limits for different detected ranges of scanning distance R(t).

Some Modifications Which Readily Come To Mind

While the illustrative embodiments disclosed the use of a 1D laser scanning module to detect visible and/or invisible bar code symbols on objects, it is understood that a 2D or raster-type laser scanning module can be used as well, to scan 1D bar code symbols, 2D stacked linear bar code symbols, and 2D matrix code symbols, and generate scan data for decoding processing.

While an illustrative range of scan angles have been disclosed herein for hand-held scanning applications, it is understood that other values can be used as required by the end-user application.

While hand-supportable laser scanning systems have been illustrated, it is understood that these laser scanning systems can be packaged in a portable or mobile data terminal (PDT) where the laser scanning engine begins to scan in response to receiving a request to scan from the host computer 154 within the PDT. Also, the laser scanning system can be integrated into modular compact housings and mounted in fixed application environments, such as on counter-top surfaces, on wall surfaces, and on transportable machines such as forklifts, where there is a need to scan code symbols on objects (e.g. boxes) that might be located anywhere within a large scanning range (e.g. up to 20+ feet away from the scanning system). In such fixed mounted applications, the trigger signal can be generated by manual switches located a remote locations (e.g. within the forklift cab near the driver) or anywhere not located on the housing of the system.

Also, the illustrative embodiment have been described in connection with various types of code symbol reading applications involving 1-D and 2-D bar code structures (e.g. 1D bar code symbols, 2D stacked linear bar code symbols, and 2D matrix code symbols), it is understood that the present invention can be used to read (i.e. recognize) any machine-readable indicia, dataform, or graphically-encoded form of intelligence, including, but not limited to bar code symbol structures, alphanumeric character recognition strings, handwriting, and diverse dataforms currently known in the art or to be developed in the future. Hereinafter, the term "code symbol" shall be deemed to include all such information carrying structures and other forms of graphically-encoded intelligence.

It is understood that the digital-imaging based bar code symbol reading system of the illustrative embodiments may be modified in a variety of ways which will become readily apparent to those skilled in the art of having the benefit of the novel teachings disclosed herein. All such modifications and variations of the illustrative embodiments thereof shall be deemed to be within the scope of the Claims appended hereto.

WHAT IS CLAIMED IS:

1. A method of reading code symbols using a laser scanning code symbol reading system having a working distance, said method comprising the steps of:

(a) supporting adjacent an object with a code symbol, in proximity to a hand-supportable laser scanning code symbol reading system having a light transmission window, and a scan line data buffer;

(b) estimating the distance of said object from said light transmission window, and generating data representative of said estimated distance;

(c) projecting a laser scanning beam through said light transmission window, and having a scan angle that is determined by said estimated distance, or said data representative of said estimated distance;

(d) detecting the intensity of laser light reflected/scattered from said scanning field during the scan sweep of the laser scanning beam across said scanning field and any object in said scanning field, and generating scan data signal representative of the detected laser light;

(e) collecting a line of scan data over a sweep of the laser beam across the scanning field and any object therein, and buffering the collected line of scan data; and

(f) decode processing said line of scan data collected and buffered in step (e) in an attempt to read any code symbol represented in said line of scan data, and when a code symbol is read within said line of scan data, then generating and transmitting symbol character data, corresponding to said decoded code symbol, to its intended destination.

2. The method of Claim 1, wherein said scan angle determined by said estimated distance in step (b) is selected to achieve a predetermined scan line length projected onto the object scanned by said laser scanning beam during step (c).

3. The method of Claim 1, wherein the length of the scan line projected onto the object scanned by the laser scanning beam is substantially constant for a range of object distances from the light transmission window, over a substantial portion of the working range of said laser scanning code symbol reading system.

4. The method of Claim 1, wherein the length of the scan line projected onto the object scanned by the

laser scanning beam is substantially constant for a range of object distances from the light transmission window, over a limited portion of the working range of said laser scanning code symbol reading system.

5. The method of Claim 1, wherein said code symbols are symbols selected from the group consisting of 1D bar code symbols, 2D stacked linear bar code symbols and 2D matrix code symbols.

6. The method of Claim 1, wherein step (c) comprises using a scanner current drive circuit to supply different levels of drive current to an electromagnetically-driven scanning mechanism to achieve said scan angles in response to said distances estimated in step (b).

7. The method of Claim 1, wherein step (b) comprises estimating the distance of an object in said scanning field from said light transmission window, by processing said generating scan data signal representative of the detected laser light.

8. A laser scanning code symbol reading system, comprising:

a housing with a light transmission window;

a laser scanning module, disposed in said housing, for scanning, during each scanning cycle, a laser beam across a laser scanning field defined external to said light transmission window, and along a laser scan line passing through a code symbol on a scanned object in said laser scanning field;

light collection optics, disposed in said housing, for collecting light reflected/scattered from the scanned object in said laser scanning field;

a photo-detector, disposed in said housing, for detecting the intensity of collected light from said laser scanning field, and generating an analog scan data signal corresponding to said detected light intensity during laser scanning operations, during each said scanning cycle;

a scan data signal processor, disposed in said housing, for processing said analog scan data signal generating, and generating a line of scan data for each said scanning cycle;

wherein said scan data signal processor further includes a module for processing said analog scan data signal so as to estimate the distance of an object in said scanning field from said light transmission window, and generate data representative of said estimated distance;

wherein said laser scanning module further projects said laser scanning beam through said light transmission window, and having a scan angle that is determined by said estimated distance, or said data representative of said estimated distance;

a scan data buffer, disposed in said housing, for buffering each said line of scan data during each said scanning cycle;

a programmed processor, disposed in said housing, for processing each said line of scan data buffered in said scan data buffer during each said scanning cycle to decode any code symbol represented in said scan data, and generate symbol character data representative of said decode code symbol, and transmitting said symbol character data to its intended destination; and

a system controller, disposed in said housing, for controlling operations within said laser scanning code symbol reading system.

9. The laser scanning code symbol reading system of Claim 8, wherein said scan angle determined by said estimated distance is selected to achieve a predetermined scan line length projected onto the object scanned by said laser scanning beam.

10. The laser scanning code symbol reading system of Claim 8, wherein the length of the scan line projected onto the object scanned by the laser scanning beam is substantially constant for a range of object distances from the light transmission window, over a substantial portion of the working range of said laser scanning code symbol reading system.

11. The laser scanning code symbol reading system of Claim 8, wherein the length of the scan line projected onto the object scanned by the laser scanning beam is substantially constant for a range of object distances from the light transmission window, over a limited portion of the working range of said laser scanning code symbol reading system.

12. The laser scanning code symbol reading system of Claim 8, wherein said code symbols are symbols selected from the group consisting of 1D bar code symbols, 2D stacked linear bar code symbols and 2D matrix code symbols.

13. The laser scanning code symbol reading system of Claim 8, wherein said laser scanning modules comprises a scanner current drive circuit to supply different levels of drive current to an

electromagnetically-driven scanning mechanism to achieve said scan angles in response to said distances.

14. The laser scanning code symbol reading system, of Claim 8, wherein said analog scan data signal processor comprises a module for estimating the distance of an object in said scanning field from said light transmission window, by processing said generating scan data signal representative of the detected laser light.

15. The laser scanning code symbol reading system of Claim 8, which further comprises: an input/output (I/O) communication interface, disposed in said housing, for interfacing with a host system and transmitting symbol character data to said host system, via a communication link.

16. The laser scanning bar code symbol system of Claim 15, wherein said communication link is either a wired or wireless communication link.

17. The laser scanning bar code symbol reading system of Claim 8, wherein said housing is a hand-supportable housing.

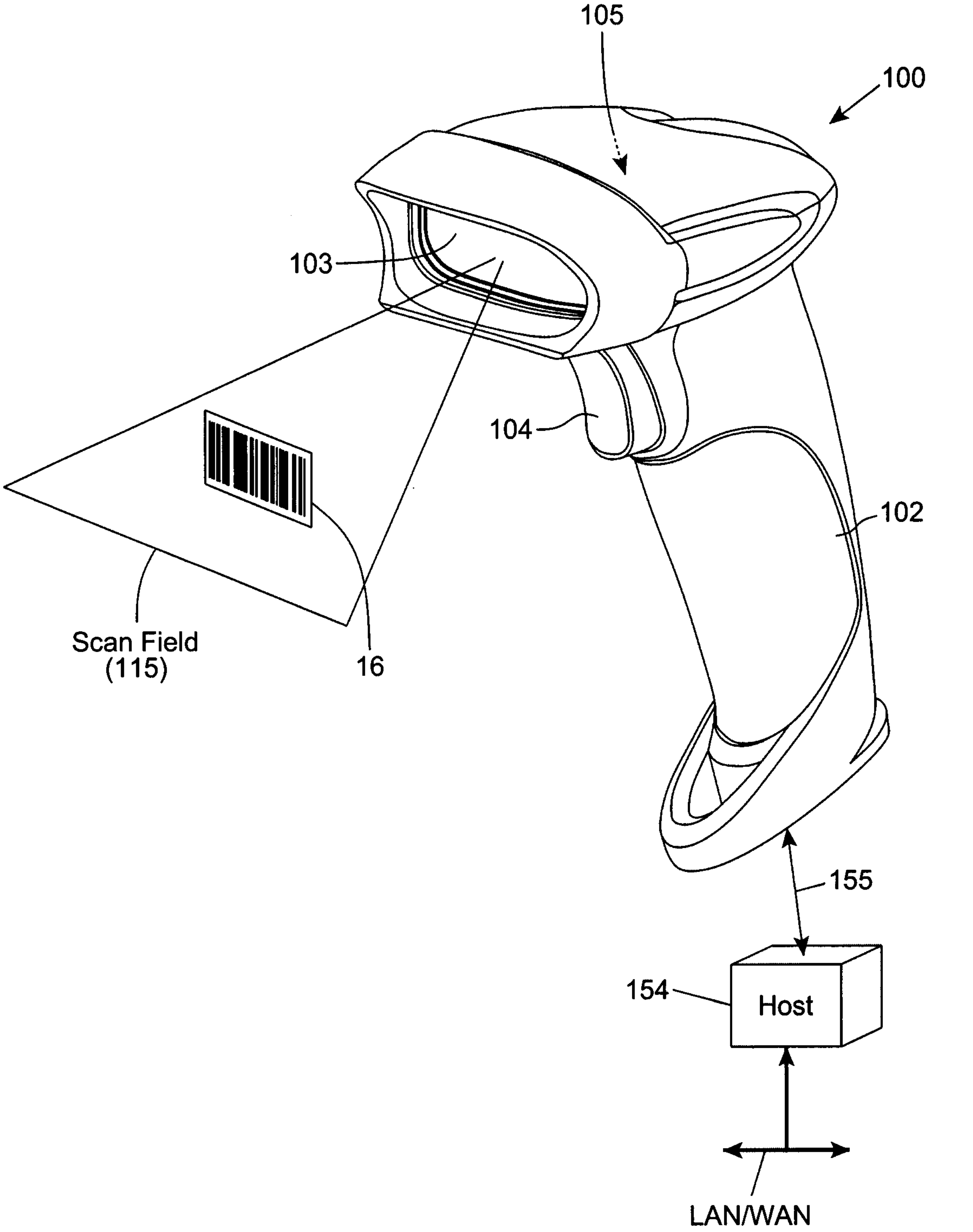


FIG. 1

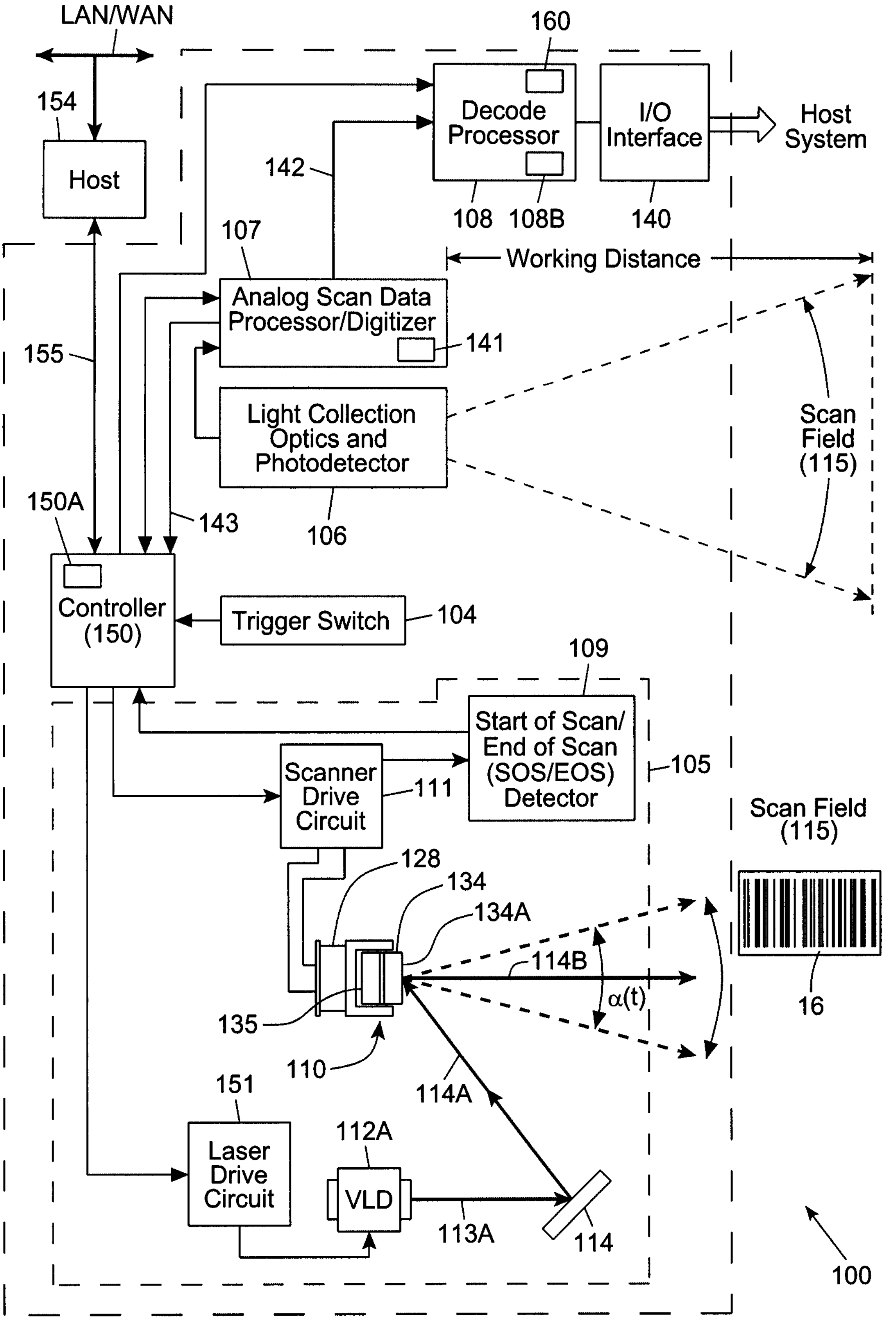
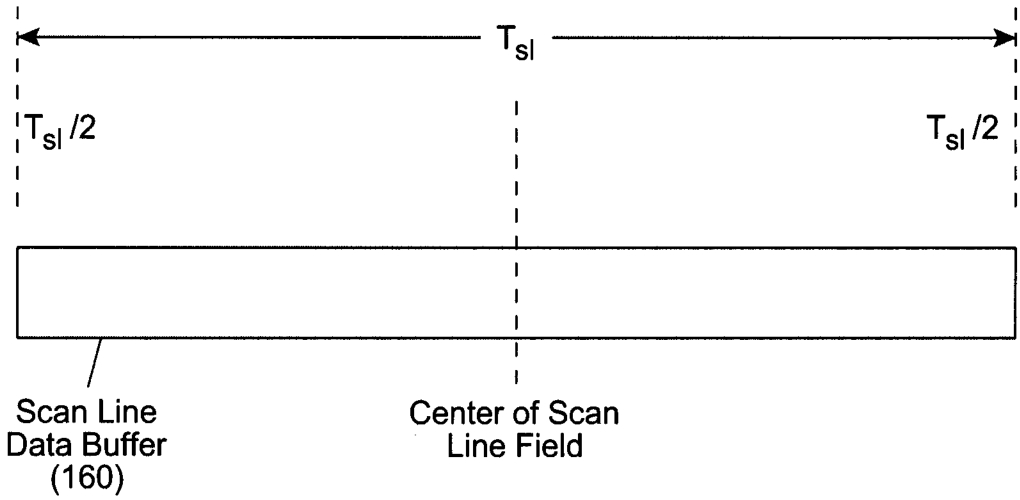
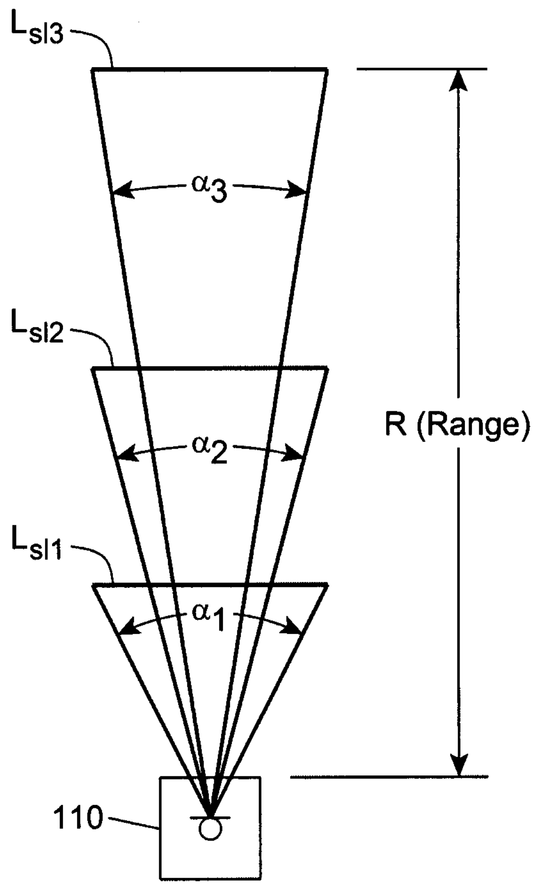

LAN/WAN
154
Host
160
Decode Processor
I/O Interface
Host System
142
108
108B
140
107
Working Distance
Analog Scan Data Processor/Digitizer
141
155
Light Collection Optics and Photodetector
Scan Field (115)
150A
143
106
Controller (150)
Trigger Switch
104
109
Start of Scan/ End of Scan (SOS/EOS) Detector
105
Scanner Drive Circuit
111
Scan Field (115)
128
134
134A
114B
α(t)
16
135
110
114A
151
Laser Drive Circuit
112A
VLD
113A
114
100

FIG. 2



T_{sl}
T_{sl} /2
T_{sl} /2
Scan Line Data Buffer (160)
Center of Scan Line Field

FIG. 3



L_{sl3}
α_3
L_{sl2}
α_2
R (Range)
L_{sl1}
α_1
110

FIG. 4

Method of Controlling Laser Scanning Bar Code Symbol Reader Employing Intelligent Scan Line Length Control

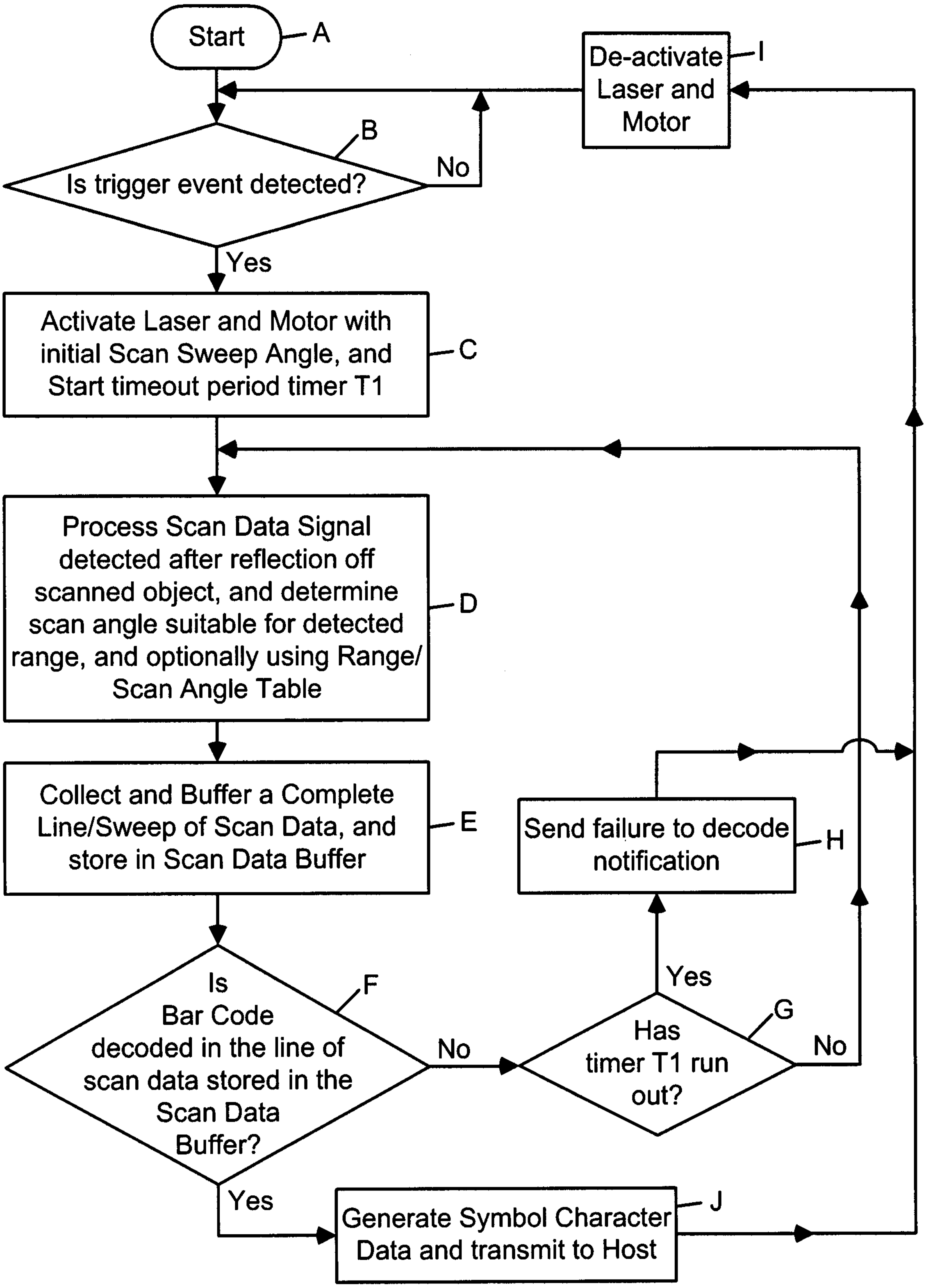


FIG. 5

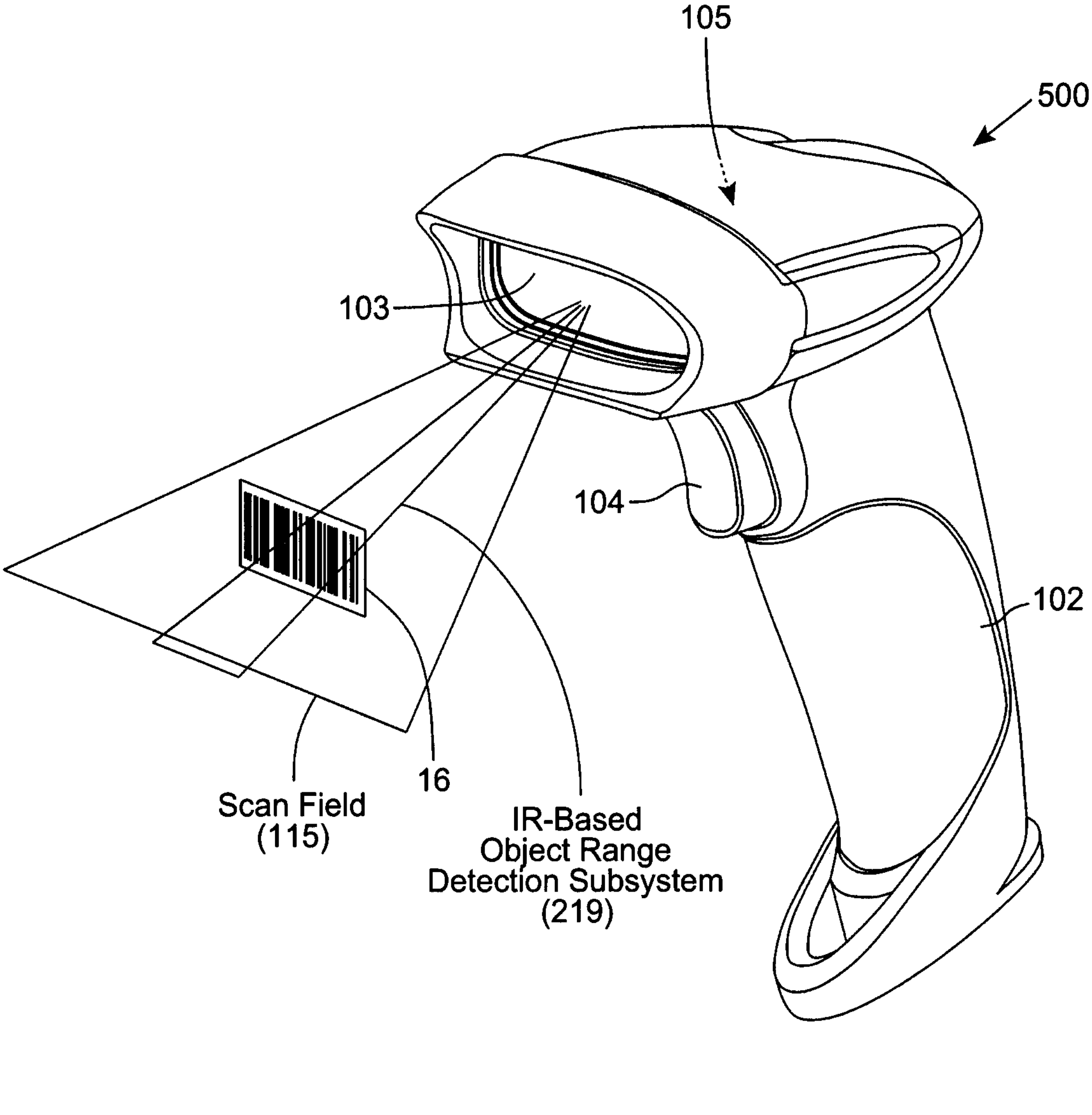

105
500
103
104
102
Scan Field
(115)
16
IR-Based
Object Range
Detection Subsystem
(219)

FIG. 6

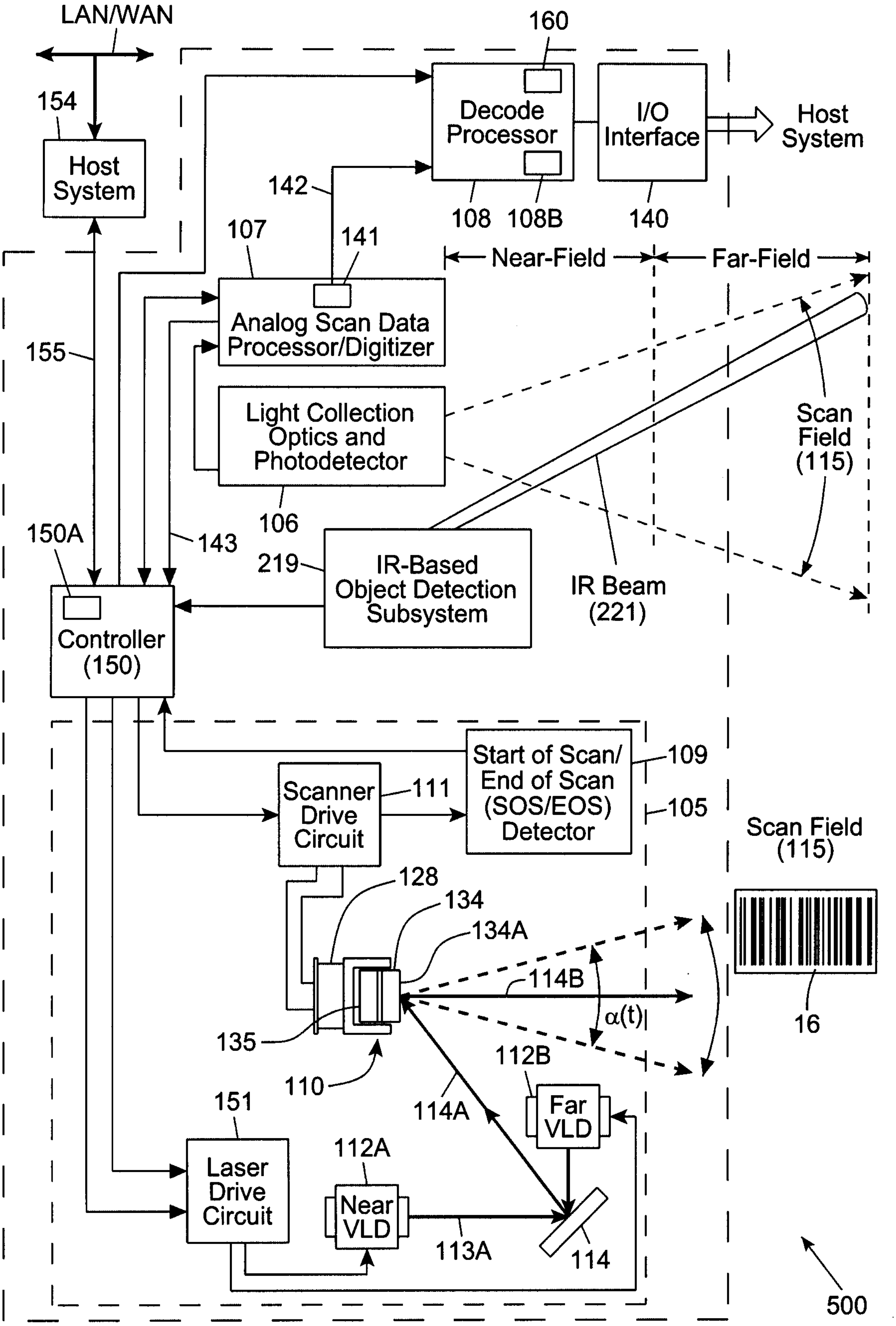

LAN/WAN
160
154
Host System
Decode Processor
I/O Interface
Host System
142
108 108B 140
107
141
Near-Field
Far-Field
155
Analog Scan Data Processor/Digitizer
Light Collection Optics and Photodetector
Scan Field (115)
106
150A
143
219
IR-Based Object Detection Subsystem
IR Beam (221)
Controller (150)
Start of Scan/ End of Scan (SOS/EOS) Detector
109
Scanner Drive Circuit
111
105
Scan Field (115)
128
134
134A
114B
α(t)
16
135
112B
110
114A
Far VLD
151
112A
Laser Drive Circuit
Near VLD
113A
114
500

FIG. 7

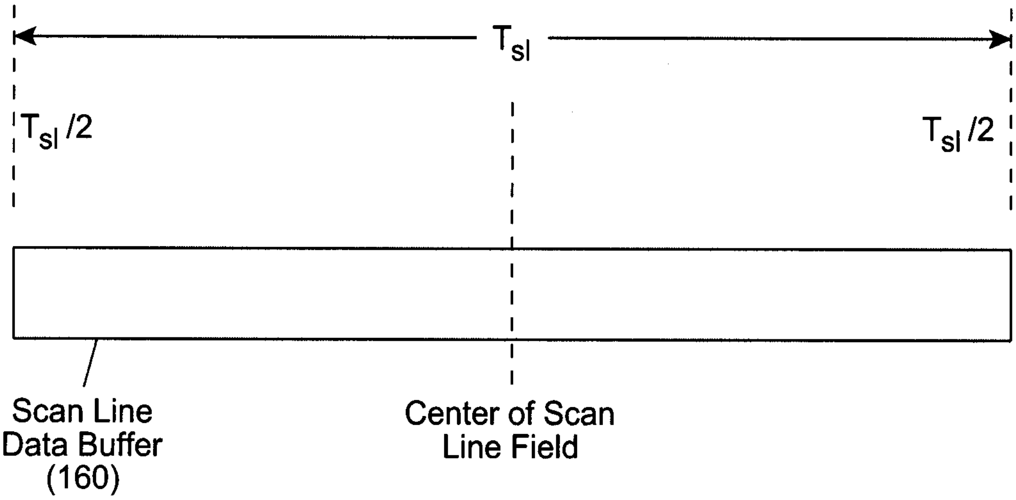

T_{sl}
$T_{sl}/2$
$T_{sl}/2$
Scan Line Data Buffer (160)
Center of Scan Line Field

FIG. 8

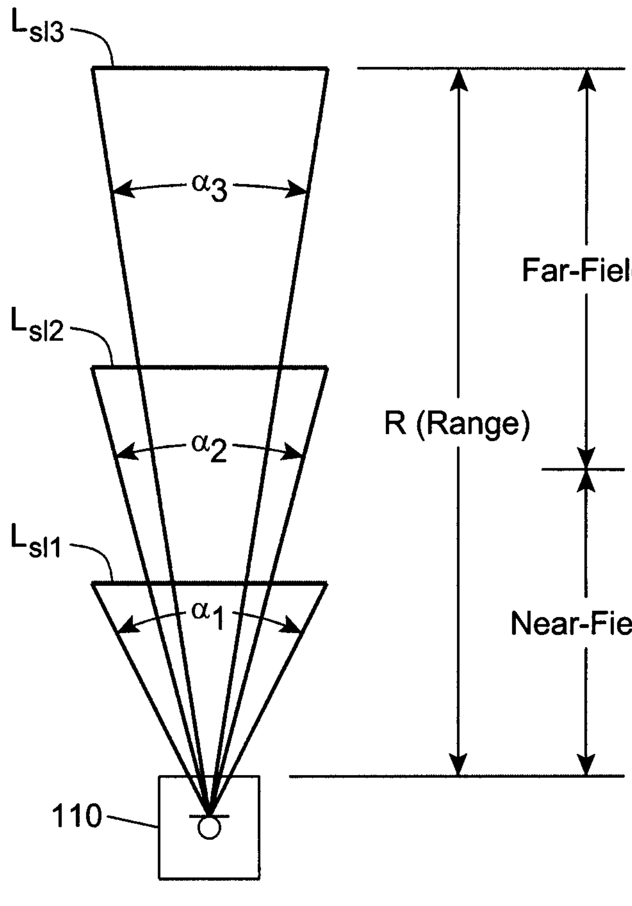

L_{sl3}
α_3
Far-Field
L_{sl2}
α_2
R (Range)
L_{sl1}
α_1
Near-Field
110

FIG. 9

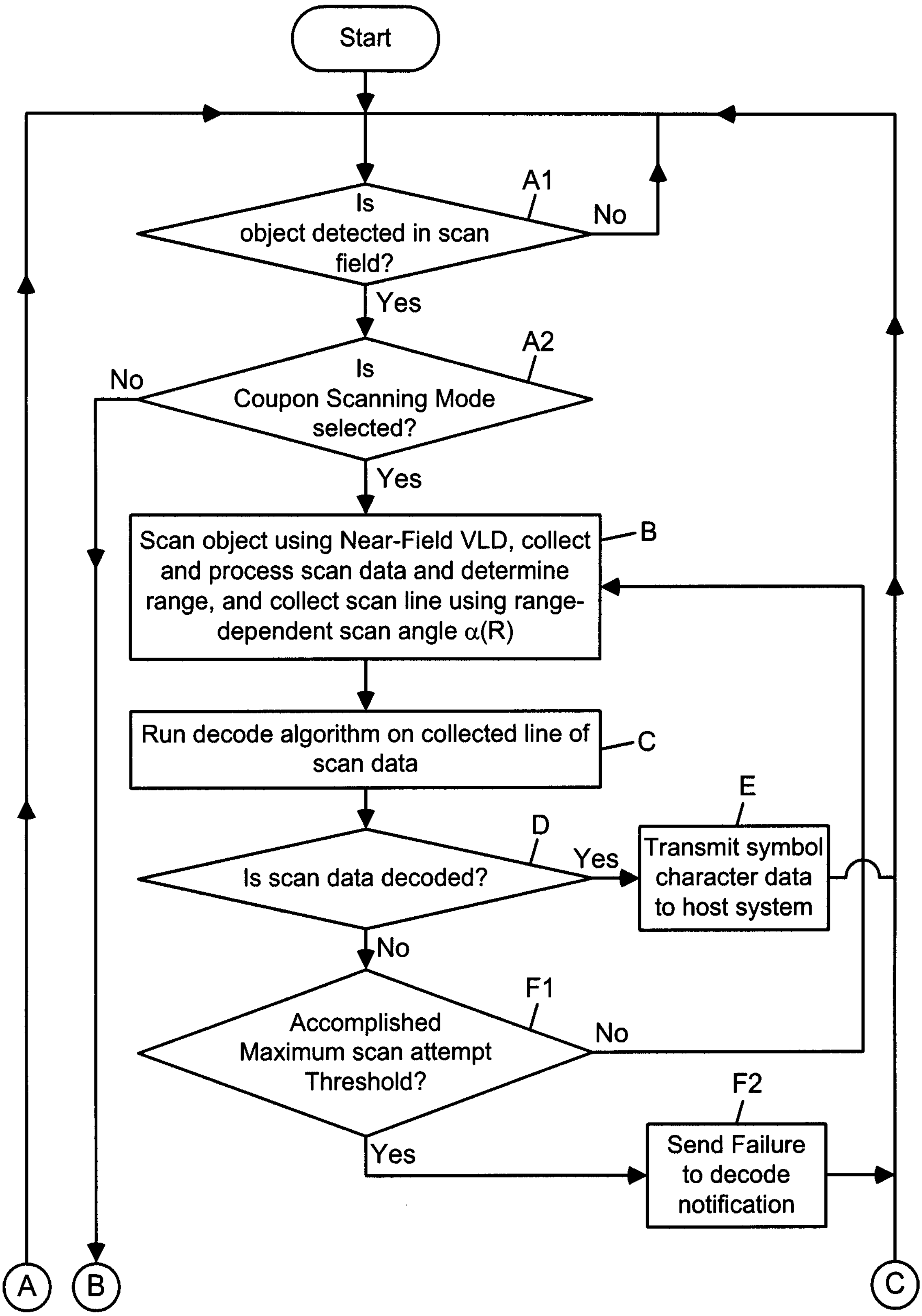

Start
Is object detected in scan field?
A1
No
Yes
Is Coupon Scanning Mode selected?
A2
No
Yes
Scan object using Near-Field VLD, collect and process scan data and determine range, and collect scan line using range-dependent scan angle α(R)
B
Run decode algorithm on collected line of scan data
C
Is scan data decoded?
D
Yes
Transmit symbol character data to host system
E
No
Accomplished Maximum scan attempt Threshold?
F1
No
Yes
Send Failure to decode notification
F2
A
B
C

FIG. 10A

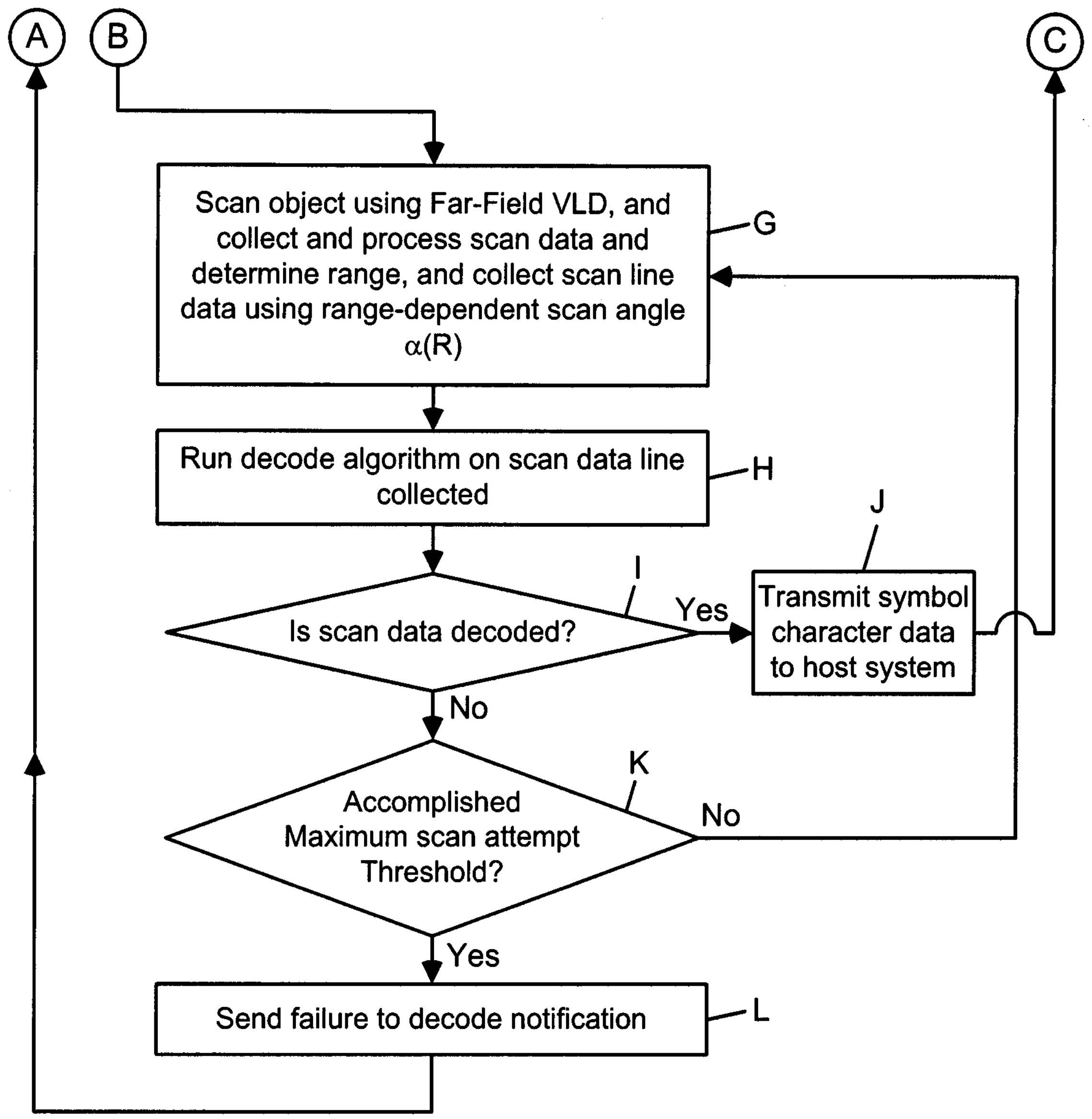

A
B
C
Scan object using Far-Field VLD, and collect and process scan data and determine range, and collect scan line data using range-dependent scan angle α(R)
G
Run decode algorithm on scan data line collected
H
J
I
Is scan data decoded?
Yes
Transmit symbol character data to host system
No
K
Accomplished Maximum scan attempt Threshold?
No
Yes
Send failure to decode notification
L

FIG. 10B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/000783

A. CLASSIFICATION OF SUBJECT MATTER

G06K 7/10(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:G06K;G02B

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 practicable, search terms used)

CNKI, CNPAT, WPI, EPODOC, IEEE: laser, code, symbol, scan+, distance, transmi+, decod+, signal?, line, estimate+, light?, detect+, field?, range, character?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US5386107A(SYMBOL TECHNOLOGIES, INC.)31 Jan.1995(31.01.1995) description, column 1, line 50 to column 2, line 2, column 3, lines 54-66, column 5, line 48 to column 6, line 33, column 8, line 35 to column 9, line 28, figures 1-5	1-17
A	JP2011154312A(NIKON CORP.)11 Aug.2011(11.08.2011)the whole document	1-17
A	CN101253510A(SYMBOL TECHNOLOGIES, INC.)27 Aug.2008(27.08.2008) the whole document	1-17
A	CN1412712A(SYMBOL TECHNOLOGIES, INC.)23 Apr.2003(23.04.2003)the whole document	1-17

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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