PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G06K 7/10, 9/00

A1

(11) International Publication Number: WO 92/05515

(43) International Publication Date: 2 April 1992 (02.04.92)

(21) International Application Number: PCT/US91/06608

(22) International Filing Date: 12 September 1991 (12.09.91)

(30) Priority data:
583,421 17 September 1990 (17.09.90) US

(71) Applicant: METROLOGIC INSTRUMENTS, INC. [US/US]; Coles Road at Route 42, Blackwood, NJ 08012 (US).

(72) Inventors: ROCKSTEIN, George, B. ; 210 Princeton Road, Audubon, NJ 08106 (US). WILZ, David, M., Sr. ; 10 Orion Way, Sewell, NJ 08080 (US). BUBNOSKI, David, P. ; 65 Stoneshire Drive, Glassboro, NJ 08028 (US). KNOWLES, Carl, H. ; 425 East Linden Street, Moorestown, NJ 08057 (US).

(74) Agent: PERKOWSKI, Thomas, J.; Hopgood, Calimafde, Kalil, Blaustein & Judlowe, 60 East 42nd Street, New York, NY 10165 (US).

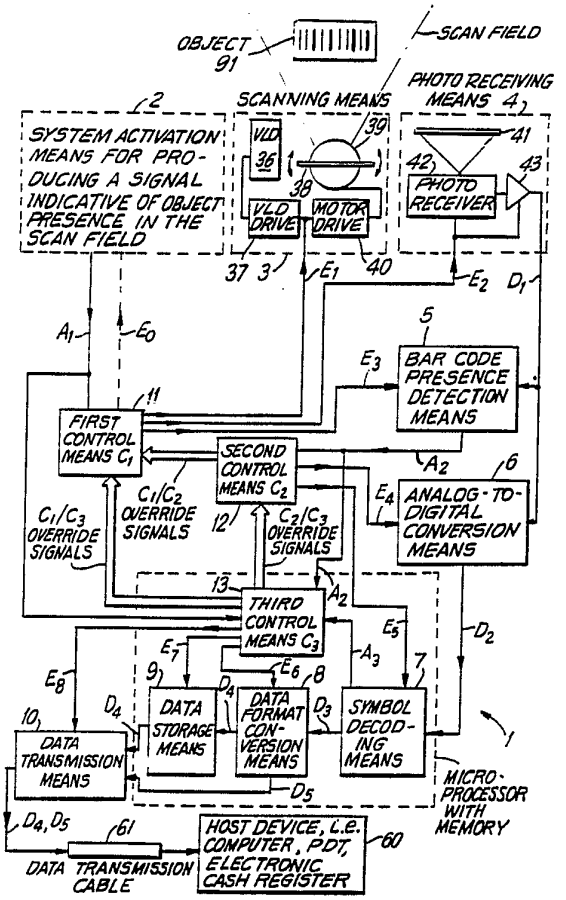
(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR AUTOMATICALLY READING BAR CODE SYMBOLS

(57) Abstract

An automatic bar code symbol reading system comprising components for carrying out object detection (2), scanning (3), photoreceiving (4), A/D conversion (6), bar code presence detection (5), symbol decoding (7), data format conversion (8), data storage (9) and data transmission functions (10). In general, the bar code symbol reading device includes a control system having a plurality of control centers (11), (12), (13) that control the operation of the system components in accordance with preselected system control operations. Each of the control centers are responsive to control activation signals generated by certain of the system components upon the occurrence of predefined conditions. Certain of the control centers are capable of overriding other control centers to provide diverse control capabilities which facilitates execution of intelligent operations and power consumption, during bar code symbol reading.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**ES**	Spain	**MG**	Madagascar
AU	Australia	**FI**	Finland	**ML**	Mali
BB	Barbados	**FR**	France	**MN**	Mongolia
BE	Belgium	**GA**	Gabon	**MR**	Mauritania
BF	Burkina Faso	**GB**	United Kingdom	**MW**	Malawi
BG	Bulgaria	**GN**	Guinea	**NL**	Netherlands
BJ	Benin	**GR**	Greece	**NO**	Norway
BR	Brazil	**HU**	Hungary	**PL**	Poland
CA	Canada	**IT**	Italy	**RO**	Romania
CF	Central African Republic	**JP**	Japan	**SD**	Sudan
CG	Congo	**KP**	Democratic People's Republic of Korea	**SE**	Sweden
CH	Switzerland			**SN**	Senegal
CI	Côte d'Ivoire	**KR**	Republic of Korea	**SU+**	Soviet Union
CM	Cameroon	**LI**	Liechtenstein	**TD**	Chad
CS	Czechoslovakia	**LK**	Sri Lanka	**TG**	Togo
DE*	Germany	**LU**	Luxembourg	**US**	United States of America
DK	Denmark	**MC**	Monaco		

+ Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

METHOD AND APPARATUS FOR AUTOMATICALLY READING BAR CODE SYMBOLS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to automatic code symbol reading (i.e. recognition) systems, and more particularly to an automatic code symbol reading device having a control system which permits multiple modes of fully automated operation while conserving power and providing versatility in its method of use.

Brief Description of the Prior Art

Hitherto, a number of techniques have been proposed for reading bar code symbols using hand-held devices. Despite variety amongst prior art bar code symbol reading devices, the various techniques incorporated into prior art devices can be classified into two principally distinct classes, namely, manually operated or triggered bar code symbol reading, and automatic bar code symbol reading.

Representative of prior art manually operated bar code symbol reading devices are U.S. Patent No. 4,387,297 to Swartz, et al., U.S. Patent No. 4,575,625 to Knowles, and U.S. Patent No. 4,845,349 to Cherry. While such prior art devices are capable of successful bar code symbol reading, they nevertheless suffer from several significant shortcomings and drawbacks. In particular, the user is required to manually pull a trigger or push a button each time scanning and decoding is to be cyclically initiated and terminated. The requirement is most fatiguing on the user when large numbers of bar code symbols are to be read. Also, in certain symbol reading applications, such as warehouse inventory, pulling the trigger to initiate

scanning of bar code symbols may be extremely difficult for the user due to the physical location of the objects bearing the bar code symbols.

An alternative to manually operated a bar code symbol reading devices is use of automatic bar code symbol readers, which incorporate techniques for automatically initiating and terminating scanning and decoding operations. Representative of prior art automatic bar code symbol devices are U.S. Patent No. 4,639,606 to Boles, et al. and U.S. Patent No. 4,933,538 to Heiman et al. While capable of automatically initiating scanning of bar code symbols, such prior art devices and incorporated techniques nevertheless also suffer from significant shortcomings and drawbacks.

In particular, U.S. Patent No. 4,639,606 to Boles, et al. discloses laser emission control circuitry for use in implementing a hand-held triggerless bar code scanner. The laser is operated in a pulsed "find paper" mode until a reflected signal is obtained, indicating the presence of an object (e.g., paper) in the search field. Thereupon, the circuitry is changed to a "search mode" in which the power of the laser is increased to above the safety limits for a period of time, and the return signal is monitored for signal transitions corresponding to the black bars of the code. On detection of the first black bar, the circuitry is changed to an "in-code" (decode) mode as long as successive symbols are received within a given period of time. If the decode mode terminates within a predetermined time interval (e.g., one second after the beginning of the search mode), then the search mode is re-entered, otherwise the decode mode will change to find paper mode.

While the triggerless bar code symbol reader proposed in U.S. Patent No. 4,639,606 possesses three modes of operation, this prior art bar code symbol reader

nevertheless suffers from several significant shortcomings and drawbacks. In particular, this prior art bar code symbol reader requires continuous use of a pulsed laser beam to determine the presence of an object within the scan field, which, in hand-held portable battery power devices, undesirably drains limited power reserves, especially in extended time duration bar code reading applications. Also, this prior art device not knowing whether a bar code symbol is actually present in the scan field, requires commencement of decode processing upon detection of the first black bar. Undesirably, this typically necessitates powering and initializing a programmable device such as a microprocessor, for decoding scan data that may likely contain no bar code symbol at all. Consequently, this characteristic of such prior art bar code symbol reading devices results in further consumption of power.

U.S. Patent No. 4,933,538 discloses a bar code symbol scanning system, which in the "object sensor mode" the scanner is triggerless and the constantly on laser beam normally emits at a narrow angle and low power. When an indicia pattern indicative of a bar code symbol has been detected, the laser beam will widen, the power of the beam will increase, and the beam will read the entire symbol. While this prior art scanning technique permits detection of bar code symbols within the scan field in order that the power of the laser beam may be automatically increased to a higher level for collecting scan data for use in decoding operations, this prior art system nevertheless suffers from several significant shortcomings and drawbacks as well. In particular, this prior art system requires continuous use of laser emission to determine the presence of both objects and bar code symbols within the scan field, which necessarily results in drain of limited power reserves in portable battery power applications. In

addition, the extensive use of a laser beam to perform object and bar code symbol detection functions implicates necessity for laser emission control measures.

In general, prior art automatic bar code symbol reading devices also suffer from other shortcomings and drawbacks. For example, unlike manually operated devices which rely on the user to activate a trigger, once for each bar code to be read, prior art triggerless (i.e., automatic) bar code symbol reading devices lack intelligence capabilities necessary to prevent undesired multiple reading of bar code symbols, particularly when the scanning beam is permitted to dwell on a bar code symbol for extended periods of time.

Further, prior art automatic bar code symbol reading devices have lacked control capabilities which permits diverse modes of programmable system-control operation, while preventing misreads and inadvertent multiple reads and ensuring conservation of power.

Thus, there is a great need in the code symbol reading art for a fully automatic code symbol reading device which overcomes the above shortcomings and drawbacks of prior art devices and techniques.

Accordingly, it is a primary object of the present invention to provide a fully automatic hand-holdable bar code symbol reading device capable of automatically reading bar code symbols in accordance with user-selectable system-control operations.

A further object of the present invention is to provide such an automatic bar code symbol reading device incorporating a control system having a plurality of control centers, each of which can be assigned predetermined control functions that enable operation of particular device components in accordance with a user-selected system-control operation.

A further object of the present invention is to provide such an automatic bar code symbol reading device, in which upon the occurrence of predetermined conditions, one or more of the control centers are capable of overriding certain of the other control centers so that a wide number of system-control operations can be carried out in a power conserving manner, to permit automatic reading of bar code symbols in a variety of diverse applications.

Another object of the present invention is to provide such an automatic bar code symbol reading device, in which the system control architecture readily permits extension of additional system-control operations by formulating and programming functions between a fixed number of control activation signals and enable signals provided as input and output signals respectively, to one or more control centers.

A further object of the present invention is to provide an automatic hand-holdable bar code symbol reading device which is capable of determining the presence of an object without enabling the scanning means of the device.

Another object of the present invention is to provide a hand-holdable bar code symbol reading device which is capable of distinguishing between a bar code symbol and a regular pattern of light and dark areas such as that formed by printed characters, and to only enable decode processing of scan data upon the detection of a bar code symbol in the scan field of the device. Consequently, the device is capable of disregarding all text within the scan field, and enabling the symbol decoder only by an actual bar code symbol.

An even further object of the present invention is to provide an automatic bar code symbol reading device which prevents multiple reading of bar code symbols due to dwelling of scanning beam upon a bar code symbol for an extended period of time.

Yet a further object of the present invention is to provide an improved method of automatically reading bar code symbols.

These and further objects of the present invention will become apparent hereinafter and in the claims.

Summary of the Invention

According to one of the broader aspects of the present invention, there is provided a fully automatic hand-holdable bar code symbol reading system.

In general, the automatic bar code reading device comprises system activation means, scanning means, photoreceiving means, analog-to-digital conversion means, bar code presence detection means, and symbol decoding means. The purpose of the system activation means is to provide a first control activation signal indicative of the presence of an object in the scan field. The purpose of the scanning means is to produce a light beam and scan the light beam across the scan field. The purpose of the photoreceiving means is to detect at least a portion of light of variable intensity reflected off the object in the scan field and produce an analog signal indicative of the detected light intensity. The purpose of the analog-to-digital conversion means is to convert the analog data signal into a digital data signal indicative of the detected light intensity. The purpose of the bar code presence detection means is to produce a second control activation signal upon detecting the presence of a bar code symbol on the object in the scan field, on the basis of the analog or digital data signal. The purpose of the symbol decoding means, on the other hand, is to produce symbol character data and a third control activation signal upon decoding a bar code symbol on the basis of the digital data signal. Notably, the produced symbol character data will correspond to the decoded bar code symbol.

Another aspect of the present invention is to embed the above-described system components within a control system having individual control centers, each of which are responsive to particular control activation signals generated by the system components. In accordance with the architecture of the control system, certain of the control centers can override other control centers, providing a marked increase in system-control operation and versatility.

Based on the control system of the present invention, it is yet further possible to now read bar code symbols in a fully automatic manner without risk of inadvertent multiple reads and the like, owing to the fact the control architecture of the present invention provides intelligence capabilities to the system.

Brief Description of the Drawings

For a fuller understanding of the objects of the present invention, the Detailed Description of the Preferred Embodiment will be taken in connection with the drawings, wherein:

FIG. 1A is a perspective view of an automatic hand-holdable laser bar code symbol reading device constructed in accordance with the principles of the present invention;

FIG. 1B is a cross-sectional elevated side view along the longitudinal extent of the bar code symbol reading device of Fig. 1A, showing various hardware and software components used in realizing the illustrated embodiment;

FIG. 1C is a cross-sectional plan view along the longitudinal extent of the bar code symbol reading device of Figs. 1A and 1B, also showing the various components used in realizing the illustrated embodiment;

FIG. 2 is block functional system diagram of the bar code symbol reading device of the present invention,

illustrating the principal components of the device as being integrated within the control system hereof;

FIG. 3A is a block functional diagram of a first embodiment of the system activation means of the bar code symbol reading device of the present invention;

FIG. 3B is a block functional diagram of a second embodiment of the system activation means of the present invention;

FIG. 4 is a block functional diagram of the bar code presence detection means of the bar code symbol reading device of the present invention;

FIG. 5 is a logical functional diagram of the first control means of the control system of the present invention;

FIG. 6 is a logical function diagram of the second control means of the control system of the present invention;

FIG. 7A is a functional block diagram of the third control means of the control system of the present invention;

FIG. 7B is a flow chart of a control program carried out in the third control means for the case of system-control operation No. 2 (i.e., path option 2) of the illustrated embodiment;

FIGS. 8A, 8B and 8C, taken together, show a high level flow chart illustrating three user-selectable courses of programmed system operation that the control system of the illustrated embodiment may undergo;

FIG. 9 is a state diagram illustrating the various states that the bar code symbol reading device of the illustrated embodiment may undergo during the course of its operation; and

FIG. 10 is a perspective view of a surface-mountable support stand adapted for receipt of the hand-held bar code symbol reading device of the present invention and facilitating table top use thereof.

Detailed Description of the Preferred Embodiment

The automatic bar code symbol reading system 1 of the present invention, is generally illustrated in Figs. 1 through 10.

As shown in Fig. 2, bar code symbol reading system 1 comprises a number of system components, namely, system activation means 2, scanning means 3, photoreceiving means 4, bar code presence detection means 5, analog-to-digital (A/D) conversion means 6, symbol decoding means 7, data format conversion means 8, symbol character data storage means 9, and data transmission means 10. As illustrated, these system components are embedded within a programmable control system having a unique architecture which provides a great degree of versatility in system capability and operation, as well as power conservation. The structure, function and advantages of this control system architecture will be described in great detail hereinafter.

The control system of the present invention comprises essentially three major components, namely first control means (C_1) 11, second control means (C_2) 12, and third control means (C_3) 13. As will be described in greater detail hereinafter, second control means 12 is capable of "overriding" (i.e., exhibit and/or enable) first control means 11, whereas third control means 13 is capable of overriding second control means 12 and first control means 11. As shown in Fig. 2, such control override functions are carried out by the generation of control override signals (i.e., C_1/C_2, C_1/C_3, and C_2/C_3) transmitted between respective control structures.

While not illustrated in the drawings for purposes of clarity and avoidance of obfuscation, automatic bar code symbol reading device 1 includes a conventional power supply which is capable of providing requisite power to each of the system components, when and for time

prescribed by the control system hereof. Typically, an on/off power switch or functionally equivalent device will be provided external to housing 14 to permit the user to turn on device 1. When power switch is initially engaged to its ON position, power will only be provided to system activation means 2 to enable its operation, while, for example, only biasing voltages and the like are provided to all other system components so that they are each initially disabled from operation.

In accordance with the present invention, the purpose of system activation means 2 is to produce first control activation signal A_1 upon determining (i.e., detecting) the presence of an object (e.g., product, document, etc.) within the scan field of bar code symbol reading device 1, as illustrated in Fig. 1A. In turn, first control activation signal A_1 is provided as input to both first and third control means 11 and 13, respectively. In Figs. 3A and 3B, two different approaches to generating first control activation signal A_1 are disclosed.

In Fig. 3A, a passive technique is illustrated, in which passive detection of ambient light within the scan field is performed in order to determine if an object is present within the scan field of the automatic bar code symbol reading device 1. As illustrated in Fig. 3A, passive ambient light detection circuit 2A comprises a pair of photo diodes 15A and 15B, which sense ambient light gathered from two different parts of the scan field in front of device 1, using focussing lenses 16A and 16B, respectively. The output signals of photodiodes 15A and 15B are converted to voltages by current-to-voltage amplifiers 17A and 17B respectively, and are provided as input to a differential amplifier 18. The output of differential amplifier 18 is provided as input to a sample and hold amplifier 19 in order to reject 60 and 120 Hz noise. Output signal of amplifier 19 is provided as input

to a logarithmic amplifier 20 to compand signal swing. The output signal of logarithmic amplifier 20 is provided as input to a differentiator 21 and then to a comparator 21. The output of comparator 21 provides first control activation signal A_1.

In Fig. 3B, an active technique is illustrated in which an infrared signal is transmitted out into the scan field and first control activation signal A_1 is generated upon receiving a reflection of the transmitted signal off an object within the scan field. As illustrated in Fig. 3B, infrared object detection circuit 2B comprises a synchronous receiver/transmitter 22, which includes an infrared LED 23 which generates a 900 nanometer pulsed signal at a rate of 2.0 KHZ. This pulsed signal is transmitted through focusing lens 23 to illuminate the scan field. When an object is present within the scan field, a reflected pulse signal is produced and focussed through focusing lens 24 onto photodiode 25. The output of photodiode is corrected to a voltage by current-to-voltage amplifier 26, and the output thereof is provided as input to receiver/transmitter 22, to synchronously compare the received signal with the transmitted signal and determine if an object is present in the scan field. If so, then synchronous receiver/transmitter 22 produces first control activation signal $A_1=1$ indicative of such condition. First control activation signal $A_1=1$ upon being generated activates first control means 11 which, in turn, enables operation of scanning means 3, photoreceiving means 4, and bar code presence detection means 5, as will be described in greater detail hereinafter. In order to conserve power and improve signal-to-noise ratio at photoreceiving means 4 during scan data collection operations, it is preferable for first control means 11 to generate and provide a disable signal E_0 to infrared object

detection circuit 2B whenever first control means 11 enables the scanning means 3.

As illustrated in Figs. 2 and 5, first control means 11 is preferably realized by a circuit capable of generating enabling signals E_1, E_2 and E_3 for the scanning means, photoreceiving means and bar code presence detection means, respectively. As will be described in detail hereinafter, the specific operation of first control means 11 is dependent on the state of three sets of input signals, namely, first control activation signal A, C_1 override signals from C_2 (i.e., C_1/C_2 inhibit signal and C_1/C_2 enable signal), and C_1 override signals from C_3 (i.e., C_1/C_3 inhibit signal and C_1/C_3 enable signal). As shown, first control activation control signal A_1 is provided to the "START" input of timer 28 upon which it produces a "high" output signal for a first predetermined time period (i.e., T_1 seconds). Preferrably, time period T_1 is selected to be about 0.3 seconds.

As illustrated in Fig. 5, the output signal of timer 28 is provided as an input to AND gate 29, with its other input connected to the RESET input of timer 28. The output of AND gate 29 is provided as an input to each of OR gates 30, 31 and 32. C_1/C_2 inhibit signal from second control means 12 and C_1/C_3 inhibit signal from third control means 13 are provided as inputs to NOR gate 33, whereas C_1/C_2 enable signal from second control means 12 and C_1/C_3 enable from third control means 13 are provided as inputs to OR gate 34. As shown, the output signal of OR gate 34 is provided to the other input of OR gates 30 and 31, whereas the output signal from NOR gate 33 is provided as input to AND gate 29. C_1/C_3 enable signal is also provided as input to OR gate 32, to complete the description of the circuit realization of first control means 11. As indicated in Fig. 5, the outputs of OR gates 30, 31 and 32 provide enable signals E_1, E_2 and E_3 for the

scanning means, photoreceiving means and bar code presence detection means, respectively. Notably, disable signal E_0 is produced from the output of OR gate 30.

As illustrated in Fig. 2, scanning means 3 comprises a light source 36 which, in general, may be any source of intense light suitably selected for maximizing the reflectively from the object. In the preferred embodiment, light source 36 comprises a solid-state visible laser diode (VLD) which is driven by a conventional driver circuit 37. In order to deflect the laser beam output from laser diode 36 over a scan field having a predetermined spatial extend in front of front portion 14A of housing 14 in Fig. 1A, a conventional scanning mirror 38 can be oscillated back and forth by a stepper motor 39 driven by a conventional driver circuit 40, as shown. However, one of a variety of conventional scanning mechanisms may be alternatively used with excellent results. To selectively activate both laser light source 36 and motor 39, scanning means enable signal E_1 is provided as an input to both driver circuits 37 and 40. When enable signal E_1 is a logical "high" level (i.e., E_1=1), scanning means 3 is operable, a laser beam is generated and scanned across the scan field, and scan data is thereby produced off any object residing within the scan field.

In a conventional manner, when an object, such as product bearing a bar code symbol, is within the scan field at the time of scanning, the laser beam incident thereon will be reflected, producing a laser light return signal of variable intensity which represents a spatial variation of light reflectivity characteristic of the spaced apart pattern of bars comprising the bar code symbol. Photoreceiving means 4 is provided for the purpose of detecting at least a portion of laser light of variable intensity, which is reflected off the object and bar code

symbol within the scan field. Upon such detection, photo receiving means 4 produces an analog data signal D_1 indicative of the detected light intensity. In general, photoreceiving means comprises scan data collection optics 41, such as a focusing mirror, which focus scan data signals for subsequent detection by a conventional photo receiver 42. Photoreceiver 42 in turn, produces an analog signal indicative of the intensity of the scan data signal, which is subsequently amplified by preamplifier 43 to produce analog scan data signal D_1. In combination, scanning means 3 and photoreceiving means 4 operate to generate scan data from the scan field, over time intervals specified by first control means 11 during normal (i.e., noncontrol-override) modes of operation, and by third control means 13 during "control override" modes of operation. As will illustrated hereinafter, this scan data is used by both bar code presence detection means 5 and symbol decoding means 6.

As illustrated in Fig. 2, analog scan data signal D_1 is provided as input to both bar code presence detection means 5 as well as A/D conversion means 6. The primary purpose of bar code presence detection means 5 is to determine whether a bar code is present in or absent from the scan field, over time intervals specified by first control means 11 during normal modes of operation and by third control means 13 during control override modes of operation. When the presence of a bar code symbol in the scan field is determined, the bar code presence detection means 5 generates second control activation signal A_2 (i.e., A_2=1) which is provided as input to second control means 12, as shown in Fig. 2.

As illustrated in Fig. 4, bar code presence detection means 5 is provided with enable signal E_3 which is used to enable circuitry employed in the realization of the bar code presence detection means. In the preferred

embodiment, bar code presence detection means 5 is realized as a bar code envelope detector which processes analog scan data signal D_1 so as to produce a signal, the intensity of which indicates the general envelope of a bar code within the scan field. Upon such detection, bar code envelope detector 5 produces second control activation signal A_2=1 which is provided as input to second control means 12.

As shown in Fig. 3, analog scan data signal D_1 is provided as input to a differentiater 44 comprising capacitance element C_1 and resistive element R_1, to produce the first derivative signal of signal D_1. The first derivative signal is then amplified by a differential output amplifier 45, to produce as output amplified positive and negative first derivative signals, which in turn are provided as input to a positive peak detector 46. The output signal of positive peak detector 46 is provided as input to a compariter 47 which generates positive and negative bar code detect (BCD) signals.

As illustrated in Fig. 4, the positive and negative BCD signals are then provided as input and RESET signals to both integraters 48A and 48B. Positive BCD signal is also provided as input to pulse generator 50, which generates pulses upon the detection of the negative edges of the positive BCD signal. As shown, the output signals of integraters 48A and 48B are provided as first inputs to compariters 49A and 49B respectively, whereas an envelope border threshold voltage V_1 and bar code threshold voltage V_2 are provided as second inputs to compariters 49A and 49B, respectively. Boarder voltage V_1 is a DC reference voltage whose value can be determined on the basis of the time constant of intergrater 48A, its gain, and the time duration of the minimum required "boarder width" of the bar code symbol. Bar code threshold V_2 is also a DC reference voltage whose value can be determined on the

basis of the time constant of intergrater 48B, its gain, and the time duration of the minimum required "bar code length".

The output of compariters 49A and 49B are provided to the S gates of latches 51 and 52, respectively, and the Q gates of these latches are provided as inputs to AND gate 53, as shown in Fig. 4. The output of AND gate 53 is provided as input to the S gate of latch 54, whereas the R gate of latch 54 is connected to the R gate of latch 51. The output of pulse generator 50 is provided as input to the R gate of latch 52. The output of latch 54 provides second control activation signal A_2, which in turn, is provided as input to second control means 12, as shown in Fig. 2. The operation of the bar code envelope detector 5 is essentially as follows. If the output signals of both compariters 49A and 49B go "high" before the next RESET pulse from pulse generator 50 is provided to latch 52, then the output of latch 54 will go "high" (i.e., A_2=1) indicating that a bar code is present in the scan field.

In general, when the presence of a bar code in the scan field is detected, second activation control signal A_2 is generated, second control means 12 is activated and first control means 11 is overridden by second control means 12 through the transmission of control override signals (i.e., C_1/C_2 inhibit and C_1/C_2 enable signals) from the second control means.

As illustrated in Fig. 6, second control means 12 preferably includes a timing means 55 whose output signal remains high for a second predetermined time period T_2. Preferrably, time period T_2 is selected to be about 1.0 seconds. Second control activation signal A_2 is provided to the start input of timing means 55, while the output thereof is provided as an input to AND gate 56, as shown. Third control means 13 provides a pair of C_2 override signals (i.e., C_2/C_3 A and $C_2/_3$B), as input to second

control means 12, as shown in Fig. 2. The C_2/C_3 inhibit signal is provided to the second input of timing means 55. The C_2/C_3 enable signal, on the other hand, is provided to the first input of OR gates 57 and 58, whereas the output of AND gate 56 is provided as second input to each of OR gates 57 and 58. As illustrated in Fig. 6, the output signal of timing means provides both C_1/C_2 inhibit and C_1/C_2 enable signals, whereas the output of OR gates 57 and 58 provides enable signals E_4 and E_5 for enabling A/D conversion means 6 and symbol decoding means 7, respectively.

Upon detecting the presence of a bar code in the scan field, second control activation signal A_2 activates second control activation means 12, which, in turn, directly enables A/D conversion means 6 and symbol decoding means 7 by enabling signals E_4 and E_5, respectively. Indirectly, second control means 12 enables scanning means 3 and photoreceiving means 4 and disables bar code presence detection means 5 by providing C_1 override signals to first control means 11.

A/D conversion means 7 can be realized by any conventional A/D circuit or chip, and functions to convert analog scan data signal D into a digital scan data signal D_2, corresponding to the detected intensity of laser light collected and detected at photoreceiving means 4. The digitized scan data signal D_2 is provided as input to symbol decoding means 7, which scan line by scan line, decodes processes in a conventional manner, the stream of digitized scan data. The decoding means 7 processes a scan line of the digital scan data at a time, in an attempt to decode a valid bar code symbol within the second predetermined time period T_2 established and monitored by timing means 55 of second control means 12. If decoding means 7 successfully decodes a bar code symbol within time period T_2, symbol character data D_3 (typically

in ASCII code format) is produced corresponding to the decoded bar code symbol. Thereupon third control activation signal A_3 is produced by symbol decoding means 7 and is provided to third control means 13 to activate the same. In response, third control means 13 provides override control signals to first control 11 and second control means 12, as described hereinabove.

As illustrated in Figs. 2 and 7, third control means 13 of the illustrated embodiment generates and provides enable signals E_6, E_7 and E_8 to data format conversion means 8, data storage means 9 and data transmission means 10. As shown, symbol decoding means 7 provides symbol character data D_3 to data format means 8 to convert data D_3 into two differently formatted types of symbol character data, namely D_4 and D_5. Format-converted symbol character date D_4 is of the "packed data" format, particularly adapted for efficient storage in data storage means 9. Format-converted symbol character data D_5 is particularly adapted for data transmission to a host device 60, such as a computer, or electronic cash register. When symbol character data D_4 is to be converted into the format of the users choice based on a selected option mode, third control means 13 generates and provides enable signal E_6 to data storage means 9, as shown in Fig. 2. Similarly, when format converted data D_5 is to be transmitted to host device 60, the third control means 13 generates and provides enable signal E_8 to data transmission means 10, which thereupon transmits format-converted symbol character data D_5 to host device, via a conventional data transmission cable 61.

In the illustrated embodiment, third control means 13, symbol decoding means 7, and data format conversion means 8 and data storage means 9 are realized using a single programmable device, such as a microprocessor 63 having accessible memory and external timing means. In this way,

conventional symbol decoding and data format conversion processing can be implemented in a straightforward manner. As for the programming microprocessor to realize third control means 13 and the control functions which it performs in the illustrated embodiment, reference is made to Fig. 2, 5, 6, 7A and 7B in particular. In order to illustrate the nature of this programming and how it can be realized starting from a high level flow chart, System-Control Operation No. 2, illustrated in Figs. 8A and 8B, will be used as an example.

In Fig. 7A, the third control means is shown implemented with a timer 64 and microprocessor 63, whose input pins I_1 through I_4 and output pins O_1 through O_8 are utilized in achieving the control functions performed during System-Control Operation No. 2. In order to illustrate the programmed operation of the third control means during System-Control Operation No. 2, reference is made to Figs. 7A and 7B of the drawings.

In Fig. 7A, the output of timer 64 is provided to input pin I_4 of microprocessor 63, whereas outputs O_7 and O_8 thereof are provided as start and reset signals respectively, to timer 64 as shown. Timer 63 is selected to elapse at T_3, which preferrably will be about 2-3 seconds. Notably, each input I_1 through I_4, output O_1 through O_8, control activation signals A_1 through A_3, and enable signal E_1 through E_8, may take on either a logical "high" value (i.e., 1), or a logical "low" value (i.e., 0). As illustrated in Figs. 8A and 8B, during progression through System-Control Operation No. 2, the presence of third control activation signal A_3 (i.e., A_3=1) activates third control means 13. The presence of such signal value at the third control means indicates a valid bar code symbol has been decoded by symbol decoder 7. At the point of activation of third control means 13, the possible logical operations that may occur therewithin (illustrated

in flow chart of Fig. 7B), are dependent upon the condition of the first and second control activation signals A_1 and A_2 and the input I_4 from the output of timer 64.

As illustrated in Fig. 7B, if control activation signals A_3 input at I_3 is "low" (i.e., A_3=0), then the control program of the third control means returns to "start" and once again continuously senses for the presence of third control activation signal (i.e., A_3=1). Otherwise, if third control activation signal A_3 input at I_3 is high (i.e., A_3=1), then the control program outputs O_2, O_3 and O_7 as high, inhibiting first and second control means 11 and 12, and starting timer (T_3) 64, while toggling outputs O_5 and O_6 to enable data format conversion means 8 and data storage means 9 or data transmission means 10.

Then, the control program proceeds to determine whether the first control activation signal A_1 at input I_1 is absent (i.e., A_1=0), indicative of no object in scan field; if so, then the control program resets outputs O_2 and O_3 to return control to the inhibited first and second control means, while toggling output O_8 to reset timer (T_3) 64. Otherwise, if input I_1 is high, indicative of an object in the scan field, then the control program outputs O_1 as high, enabling third control means 13 to override first control means 11, while enabling scanning means 3 photoreceiving means 4 and bar code presence detection means 5.

The control program then determines whether second control activation signal A_2 at input I_2 is low (i.e., A_2=0), indicative of no bar code present in the scan field; if so, the program resets outputs O_2 and O_3 to return control to the first and second control means, while toggling output O_8 to reset timer (T_3) 64. Otherwise, if second control activation signal A_2 at I_2 is high (i.e., A_2=1) indicative of a bar code present in the scan field,

then the control program progresses to determine whether the output of timer 64 at input I_4 has gone low, indicative of timer elapse (i.e., $t \geq T_3$). In this event, the control program resets output O_1 to disable scanning means 3, photoreceiving means 4 and bar code detection means 5. If the input at I_1 is not low (i.e., $A_1=1$) indicative of timer 64 not yet elapsed, then the control program continues to determine whether the input at I_2 has gone low ($A_2=0$), indicative that a bar code symbol is no longer in the scan field. The control program will continue to repeat the above-described decision loop until either the bar code symbol disappears from the scan field or timer 64 elapses, whichever occurs first. If after timer 64 has elapsed and output O_1 has been reset, then the control program finally enters a last decision loop, to determine if first control activation signal A_1 at input I_1 has gone low, indicative that an object is no longer in the scan field. If it has, then the control program returns to start, as indicated in Fig. 7B. Otherwise, until input I_1 goes low, indicating that an object no longer remains in the scan field, the control program will continue to progress through this decision loop.

Notably, using the high level flow charts of Figs. 8A and 8C, a control program for the third control means 13 can be implemented in a straightforward manner for System-Control Operation No. 3, illustrated in Figs. 8B and 8C.

Having described the detailed structure and internal functions of bar code symbol reading device 1, it is now proper at this juncture to describe the operation of the control system hereof, for each of the three illustrated user-selectable System-Control Operations Nos. 1, 2 and 3.

Referring to blocks A to G in Figs. 8A and 8B, Systems-Control Operation No. 1 is illustrated. Beginning at block A, hand-holdable device 1 is turned ON, which

results in system activation means 2 being enabled (i.e., ON), while the remainder of the systems components (i.e., scanning means 3, photoreceiving means 4, A/D conversion means 6, bar code detection means 5, symbol decoding means 7, data format conversion means 8, data storage means 9 and data transmission means 10), being disabled (i.e., OFF). At block B, the control system then determines whether first control means 11 detects the presence of first control activation signal (i.e., A_1=1). If not, then the control system returns to block A; otherwise, if so, then as illustrated at block C, first control means 11 directly enables scanning means 3, photoreceiving means 4 and bar code presence detection means 5.

Then at block D, second control means 12 detects the presence of second control activation signal (i.e., A_2=1) within first predetermined time period T_1. If A_2=1 is not present, then the control system returns to block A; and if so, then as indicated at block E, second control means 12 overrides first control means 11 and indirectly enables scanning means 3, photoreceiving means 4, A/D conversion means 6, and symbol decoding means 7.

At block F, third control means 13 then detect the presence of third control activation signal (i.e., A_3=1) within second predetermined time period T_2. If A_3=1 is not present within T_2, then the control system returns to block A; and if so, then as indicated at block G, third control means 13 overrides first and second control means 11 and 12, and indirectly enables data format conversion means 8, and data storage means 9 or data transmission means 10 until these functions are achieved, and therewhile disables scanning means 3, photoreceiving means 4, A/D conversion means 6 and symbol decoding means 7. Thereafter, as shown in Figs. 8A and 8B, the control system returns to block A, where only system activation means 2 is enabled.

Referring to blocks A through K in Figs. 8A and 8B, System-Control (override) Operation No. 2 is illustrated. This system-control operation offers the advantage of being able to avoid multiple reading of bar code symbols due to the scanning beam dwelling on a bar code symbol for an extended period of time.

Essentially, System-Control Operation No. 2 comprises all but the last return operation of above-described System-Control Operation No. 1 and those additional operations represented by blocks G through K. After leaving block G, third control means 13 detects the absence of first control activation signal (i.e., $A_1=0$); and if absent, then the control system returns to block A. If first control activation signal A_1 is not absent but rather present (i.e., $A_1=1$), then third control means 13 indirectly enables through overridden first control means 11, scanning means 3 and the photoreceiving means 4, and through overridden second control means 12 indirectly enables A/D conversion means 6 and bar code presence detection means 5. Thereafter, at block J, third control means 13 detects the absence of second control activation signal (i.e., $A_2=0$) within predetermined time period T_3. If signal A_2 is absent, then the control system returns to block A; and if signal A_2 is present (i.e., $A_2=1$), then third control means 13 enters a decision loop at block K. Here, third control means 13 in override mode continually detects the absence of the first activation signal (i.e., $A_1=0$), at which time the control system returns to block A.

Referring to blocks A through G and H' through J' in Figs. 8A, 8B and 8C, System-Control Operation No. 3 is illustrated. This system-control operation offers the advantage of being able to simply read bar code symbols in inventory applications, while conserving battery power.

Essentially, System-Control Operation No. 3 comprises all but the last return operation of above-described System-

Control Operation No. 1 and those additional operations represented by blocks H' through J'. After leaving block G, third control means 13 enables, through overridden first control means 11, scanning means 3 in a pulsed mode of operation (by providing a pulsed enable signal E_1' to laser driver 37). At block H', third control means 13 also enables through overridden first control means 11, photoreceiving means 3, and through overridden second control means 12, enables bar code presence detection means 5, and A/D conversion means 6.

Thereafter at block I', third control means 13 detects the presence of second control activation means (i.e., A_2=1) within a fourth predetermined time period T_4, determined using an internal timer similar to timer (T_3) 64 in Fig. 7A. Preferrably, the time duration of T_3 is selected to be about 5-10 seconds. If signal A_2 is not present but rather absent (i.e., A_2=0), then the control system returns to block A. Otherwise, if signal A_2 is present, then third control means 13 enables, through overridden second control means 12, symbol decoding means 7. Thereafter, the control system returns to block F, shown in Fig. 8A.

Having described the operation of the control system of the bar code symbol reading device of present invention, it can also be helpful to understand the various states that device 1 may be in during the course of each particular system-control operation described above. In this regard, reference is made to Fig. 9 which provides a state diagram for the three system-control operations of the illustrated embodiment.

System-Control Operation No. 1 selected at option path 1, will be considered first. As illustrated in Fig. 9, when bar code symbol reading device is turned ON, only system activation means 2 is operative and all other system components are inoperative. This condition is indicated

by state A, in which the device seeks to determine whether an object is in the scan field. Upon determination of the presence of an object in the scan field, the device will undergo state transition B, placing the device in state C.

In state C, the device seeks to determine within line T_1 the presence of a bar code in scan field, while under the control of first control means 11. If no bar code symbol is determined to present in the scan field with time period T_1 then the device will undergo state transition D, returning the device back to initial state A (indicated as "start" in Fig. 8A). On the other hand, if a bar code symbol is determined to be present in the scan field within time period T_1, then the device will undergo state transition E, placing the device in state F.

In state F, the device collects bar code scan data D_1 under the control of second control means 12, converts scan data D_1 into scan data D_2 and decode processes this scan data, scan-line by scan-line, in an attempt to decode a valid bar code symbol within time period T_2. If a bar code symbol is not decoded within time period T_2, then the device undergoes state transition H, returning the device to initial state A. If on the other hand a valid bar code symbol is decoded within time period T_2, symbol character data D_3 produced, and then the device undergoes state transition G, placing the device on "control-override" state I.

In state I, device 1 while under control of the third control means, converts the data format of symbol character data D_3 into either data D_4 or D_5 depending on whether the converted symbol character data is to be stored or transmitted to host device 60. Also in state I, the device either stores data D_5 in storage means 9, or transmits data D_5 to host device 60 via data transmission means 10 and data transmission cable 61, shown in Fig. 2. After completion of the above functions, the device

undergoes state transition J (due to user-selection of System-Control Operation No. 1), returning the device to initial state A, completing a full path through System-Control Operation No. 1.

System-Control Operation No. 2, selected at option path 2, will now be considered. From control override state I, the device undergoes transition K, due to user-selection of System-Control Operation No. 2, placing the device in control-override state L. In state L, the device determines the presence of an object in the scan field, while under the override control of third control means 13. Upon determination of the presence of an object in the scan field device 1 undergoes state transition M, placing it into state O. On the other hand, if no object is determined to be within the scan field, then the device returns to initial state A.

In state O, the device seeks to determine the presence of a bar code symbol within the scan field, while the device is under the control of third control means 13. If the device determines that no bar code symbol is within the scan field, then the device undergoes state transition Q, returning the device to initial state A. If on the other hand the device determines that a bar code symbol lies within the scan field, indicative of the scanning beam dwelling on a bar code symbol for an extended period of time, then the device undergoes state transition P, placing device 1 in control-override state R.

In state R, the device discontinues scanning, photoreceiving and bar code presence detection functions under the control of third control means 13, and continues to sense the presence of the object in the scan field until the object is removed therefrom. When the presence of the object is no longer detected within the scan field, then the device undergoes state transition S, returning the device to initial state A.

Lastly, System-Control Operation No. 3, selected at option path 3, is now considered. From control-override state I, the device undergoes state transition T, due to user-selection of System-Control Operation No. 3, placing the device in control-override state U. In state U, scanning means 3 is enabled in a pulsed-mode of operation under control of third control 13, photoreceiving means 4 and bar code presence detection means 5 are also enabled under third control means 13, and therewhile the device seeks to detect the presence of a bar code symbol in the scan field within fourth predetermined time period T_4. If a bar code symbol is not detected within time period T_4, then the device undergoes state transition V and returns to initial state A under override control of third control means 13. If on the other hand, the presence of a bar code symbol is detected within time period T_4, then the device undergoes state transition W, placing the device in control-override state X.

In state X, bar code scan data is collected scan-line by scan-line, and each scan line of data is decode processed in order to decode a valid bar code symbol. If a bar code symbol is decoded within time period T_2, then symbol character data D_3 is produced and the device undergoes state transition Y, placing device in control-override state I under the control of third control means 13. There, symbol character data D_3 is format converted, and stored or transmitted as hereinbefore described. Thereafter, device 1 returns to state U under control of the third control means. If, however, a bar code symbol is not decoded within time period T_2, then the device undergoes state transition Z, returning the device to state A while under the control of third contact means 13.

The automatic hand-holdable bar code symbol reading device of the present invention may also be used as

stationary bar code symbol reader, as shown in Fig. 10. There, a support stand 70 is shown having a receptacle 71 for receipt of housing handle portion 14B using support stand 70, device 1 can be mounted so as to position the scan field over a counter top 80 where goods 90 bearing bar codes 91 may be passed for reading.

While device 1 of the present invention has been provided with three user-selectable system-control (i.e., intelligence) operations, additional system-control operations may be provided to the control system hereof, in a manner as discussed hereinabove.

While the particular embodiment shown and described above has proven to be useful in many application in the code symbol reading art, further modification of the present invention herein disclosed will occur to persons skilled in the art to which the present invention pertains, and all such modifications are deemed to be within the scope and spirit of the present invention defined by the appended claims.

What is Claimed Is:

1. A method of reading a bar code symbol on an object, comprising the sequence of steps:

(a) determining the presence of an object within a scan field;

(b) determining the presence of a bar code on said object within said scan field;

(c) generating bar code scan data from said bar code on said object within said scan field and collecting said bar code scan data; and

(d) processing said collected bar code scan data in order to decode a bar code symbol and upon decoding a bar code symbol producing symbol character data corresponding to said decoded bar code symbol.

2. The method of Claim 1, wherein step (a) comprises

(1) detecting differences in ambient light intensity over a predetermined period of time, and

(2) comparing said differences in ambient light intensity with a predetermined threshold.

3. The method of Claim 1, which further comprises after step (d),

(e) converting the data format of said symbol character data to a data format compatible with a host device, and storing said format converted symbol character data or transmitting said data format converted symbol character data to said host device.

4. The method of Claim 1, wherein step (b) comprises

(1) producing a laser beam and scanning said laser beam across said object within said scan field,

(2) detecting at least a portion of laser light of variable intensity reflected off said object in said scan

field and producing a scan data signal indicative of the detected light intensity, and

(3) detecting the presence of a bar code symbol on said object in said scan field on the basis of said scan data signal, and thereupon generating a bar code presence indication signal.

5. The method of Claim 3, wherein substep (b)(3) comprises processing said scan data signal on a scan line by scan line basis in order to detect the envelope of said bar code symbol within said scan field.

6. The method of Claim 4, wherein said scan data signal in substep (b)(2) is produced on a scan line by scan line basis, such that each said scan data signal comprises a stream of object scan data, and wherein substep (b)(3) comprises processing each said stream of object scan data as it is produced until the presence of said bar code symbol is detected and said bar code presence indication signal is generated.

7. The method of Claim 1, wherein step (c) comprises

(1) producing a laser beam and scanning said laser beam across said object within said scan field, and

(2) detecting at least a portion of laser light of variable intensity reflected off said object in said field and producing a scan data signal indicative of the detected light intensity, and wherein step (d) comprises

(1) processing said scan data signal in order to decode a bar code symbol and upon decoding a bar code symbol, thereupon producing said symbol character data corresponding to said decoded bar code symbol.

8. The method of Claim 7, wherein said scan data signal in substep (c)(2) is produced on a scan line by scan line

basis, such that each said scan data signal comprises a stream of object scan data, and wherein substep (d)(1) comprises processing each stream of object scan data as it is produced until a bar code symbol is decoded thereupon producing symbol character data corresponding to said decoded bar code symbol.

9. The method of Claim 4, wherein substeps (b)(2) and (b)(3) are permitted to be carried out for a first predetermined time period and if the presence of a bar code symbol is detected with said first predetermined time period, then steps (c) and (d) are permitted to occur.

10. The method of Claim 9, wherein substeps (b)(2) and (b)(3) are carried out for said first predetermined time period and if the presence of a bar code symbol is not detected within said first predetermined time period, then steps (c) and (d) are ceased to be performed and said sequence of steps is reperformed starting with step (a).

11. The method of Claim 10, wherein substeps (c)(2) and (d)(1) are carried out for a second predetermined time period and if a bar code symbol is not decoded within a second period of time, then step (d) is not thereafter performed and said sequence of steps is reperformed starting with step (a).

12. The method of Claim 1, wherein step (b) is performed only upon determining the presence of an object within said scan field.

13. The method of Claim 12, wherein steps (c) and (d) are performed only upon detecting within a first predetermined time period, the presence of a bar code on said object within said scan field, and if no bar code

presence is detected, then begin reperforming said sequence of steps starting with step (a).

14. The method of Claim 13, wherein step (e) is performed only upon decoding a bar code symbol within a second predetermined time period.

15. The method of Claim 14, which further comprises after step (c),

(f) determining the presence of an object within said scan field, and

(g) determining the presence of a bar code symbol on said object in said scan field, only if said object is determined to be in said scan field, otherwise begin reperforming said sequence of steps starting with step (a).

16. The method of Claim 15, which further comprises after step (g),

(h) determining the presence of an object within said scan field only if a bar code symbol is determined to be present in said scan field within a third period of time, otherwise begin reperforming said sequence of steps starting with step (a).

The method of Claim 16, wherein step (h) comprises determining the presence of the object in scan field until said object is absent from said field and thereupon begin reperforming said sequence of step starting with step (a).

17. The method of Claim 14, which further comprises after step (e),

(f) determining the presence of another bar code in said scan field within a fourth predetermined period of time,

and if the presence of another bar code symbol is determined, then

(g) generating bar code scan data from said bar bode within said scan field, collecting said bar code scan data and processing said collected bar code scan data in order to decode another bar code symbol, otherwise if the presence of another bar code symbol is not determined, then being reperforming said sequence of steps starting with step (a).

18. An automatic bar code symbol reading system comprising:

system activation means for producing a first control activation signal indicative of the presence of an object in said scan field;

scanning means for producing a light beam and scanning said light beam across a scan field;

photoreceiving means for detecting at least a portion of light of variable intensity reflected off the object in said scan field and producing an analog signal indicative of the detected light intensity;

analog-to-digital conversion means for converting said analog data signal into a digital data signal indicative of said detected light intensity;

bar code presence detection means capable of producing a second control activation signal upon detecting the presence of a bar code symbol on said object in said scan field on the basis of one of said analog and digital data signals; and

symbol decoding means capable of producing symbol character data and a third control activation signal upon decoding a bar code symbol on the basis of said digital data signal, said produced symbol character data corresponding to said decoded bar code symbol.

19. The automatic bar code symbol reading system of Claim 19, which further comprises first control means capable of enabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detection means upon receiving said first control activation signal; and second control means capable of overriding said first control means and enabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said symbol decoding means upon receiving said second control activation signal.

20. The automatic bar code symbol reading system of Claim 20, wherein said bar code symbol reading system further includes data storage means for storing said produced symbol character data, data format conversion means for converting data format of said symbol character data into a data format compatible with a host device, and data transmission means for transmitting said format converted symbol character data to said host device, and wherein said bar code symbol reading system further comprises third control means capable of overriding said second control means and enabling said data format conversion means and one of said data storage means and said data transmission means, upon receiving said third control activation signal.

21. The automatic bar code symbol reading system of Claim 21, wherein said third control means is further capable of disabling said scanning means, said photoreceiving means and said symbol decoding means.

22. The automatic bar code symbol reading system of Claim 22, wherein said third control means further comprises signal detection means for detecting the absence

of said first control activation signal and thereupon producing enable signals for encoding said scanning means, said photoreceiving means, said enabling analog-to-digital conversion means and said bar code presence detection means.

23. The automatic bar code symbol leading system of Claim 23, wherein said third control means further comprises

override termination means for terminating said third control means from overriding said second control means and said second control means from overriding said first control means, and

first disabling means for disabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detection means, said override termination means and said first disabling means being enabled upon detecting the absence of said second control activation signal within a predetermined time period while permitting said system activation means to detect the presence of an object in said scan field.

24. The automatic bar code symbol reading means of Claim 24, wherein said third control means further comprises second disabling means for disabling said scanning means, said photoreceiving means, said analog-to-digital conversion means, said bar code presence detecting means and said symbol decoding means upon detecting the presence of said second control activation signal from said bar code presence detecting means within said predetermined time period, while permitting said system activation means to detect the presence of an object in said scan field.

25. The automatic bar code symbol reading means of Claim 25, wherein said third control means is further capable of enabling said termination override means upon said signal detection means detecting the absence of said first control activation signal, and wherein said third control means further capable of permitting said system activation means to detect the presence of an object in said scan field while second disabling means disables said scanning means, said photoreceiving means, said analog-to-digital conversion means, said bar code presence determining means and said symbol decoding means.

26. The apparatus of claim 26, wherein said third control means further comprises

override termination means for termination said third control means from overriding said second control means and said second control means from overriding said first control means, and

first disabling means for disabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detection means, said override termination means and said first disabling means being enabled upon detecting the absence of said second control activation signal from said bar code presence detecting means within a fourth predetermined time period, and wherein, after said third control means overrides second control means and enables said data format conversion means and one of said data storage means and said data transmission means, said third control means is further capable of enabling said scanning means in a pulsed mode of operation, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detecting means, and wherein said third control means is further capable of enabling said symbol decoding means upon detecting the presence of said second

control activation signal within said fourth predetermined time period, and enabling said override termination means and first disabling means upon detecting the absence of said second control activation signal within said fourth predetermined time period.

27. Apparatus for use in a bar code symbol reading system including system activation means for producing a first control activation signal indicative of the presence of an object in said scan field, scanning means for producing a light beam and scanning said laser beam across a scan field, photoreceiving means for detecting at least a portion of light of variable intensity reflected off the object in said scan field and producing an analog signal indicative of the detected light intensity, analog-to-digital conversion means for converting said analog data signal into a digital data signal indicative of said detected light intensity, bar code presence detection means capable of producing a second control activation signal upon detecting the presence of a bar code symbol on said object in said scan field using one of said analog and digital data signals, and symbol decoding means capable of producing a third control activation signal upon decoding said bar code symbol on the basis of said digital data signal, said produced symbol character data corresponding to said decoded bar code symbol, said apparatus comprising:

first control means capable of enabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detection means upon receiving said first control activation signal; and

second control means capable of overriding said first control means and enabling said scanning means, said photoreceiving means, said analog-to-digital conversion

means and said symbol decoding means upon receiving said second control activation signal.

28. The apparatus of Claim 28, wherein said bar code symbol reading system further includes data format conversion means for converting data format of said symbol character data into a data format compatible with a host device, data storage means for storing said produced symbol character data, and data transmission means for transmitting said format converted symbol character data to said host device, and wherein said apparatus further comprises third control means capable of overriding said second control means and enabling said data format conversion means and one of said data storage means and said data transmission means upon receiving said third control activation signal.

29. The apparatus of Claim 29, wherein said third control means is further capable of disabling said scanning means, said photoreceiving means and said symbol decoding means.

30. The apparatus of Claim 30, wherein said third control means further comprises signal detection means for detecting the absence of said first control activation signal and thereupon producing enable signals for enabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detection means.

31. The apparatus of Claim 31, wherein said third control means further comprises override termination means for terminating said control means from overriding said second control means and said

second control means from overriding said first control means, and

first disabling means for disabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detection means, said override termination means and said first disabling means being enabled upon detecting the absence of said second control activation signal within a predetermined time period while permitting said system activation means to detect the presence of an object in said scan field.

32. The apparatus of Claim 32, wherein said third control means further comprises second disabling means for disabling said scanning means, said photoreceiving means, said analog-to-digital conversion means, said bar code presence detecting means and said symbol decoding means upon detecting the presence of said second control activation signal within said predetermined time period, while permitting said system activation means to detect the presence of an object in said scan field.

33. The apparatus of Claim 33, wherein said third control means is further capable of enabling said termination override means upon said signal detection means detecting the absence of said first control activation signal, and wherein said third control means further capable of permitting said system activation means to detect the presence of an object in said scan field while second disabling means disables said scanning means, said photoreceiving means, said analog-to-digital conversion means, said bar code presence determining means and said symbol decoding means.

34. The apparatus of Claim 34, wherein said third control means further comprises

override termination means for termination said third control means from overriding said second control means and said second control means from overriding said first control means, and

first disabling means for disabling said scanning means, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detection means, said override termination means and said first disabling means being enabled upon detecting the absence of said second control activation signal within a fourth predetermined time period, and wherein, after said third control means overrides second control means and enables said data format conversion means and one of said data storage means and said data transmission means, said third control means is further capable of enabling said scanning means in a pulsed mode of operation, said photoreceiving means, said analog-to-digital conversion means and said bar code presence detecting means, and wherein said third control means is further capable of enabling said symbol decoding means upon detecting the presence of said second control activation signal within said fourth predetermined time period, and enabling said override termination means and first disabling means upon detecting the absence of said second control activation signal within said fourth predetermined time period.

35. An automatic bar code symbol reading system which comprises:

object detecting means for automatically detecting the presence of an object in a scan field and thereupon generating an activation signal;

scanning means for producing a light beam and scanning said light beam across said scan field, said producing and

scanning occurring during and for not more than a first predetermined time period upon generation of said activation signal and also during and for not more than a second predetermined time period upon generation of a bar code presence indication signal;

photoreceiving means for detecting at least a portion of light of variable intensity reflected off said object in said scan field and producing an analog signal indicative of the detected light intensity, said detecting and producing occurring during and for not more than said first predetermined time period upon generation of said activation signal and also during and for not more than said second predetermined time period upon generation of said bar code presence indication signal;

analog-to-digital conversion means for converting said analog signal into a digital signal indicative of said detected light intensity, said converting occurring during and for not more than said first predetermined time period upon generation of said activation signal and also during and for not more than said second predetermined time period upon generation of said bar code presence indication signal;

bar code presence detection means for detecting, during and for not more than said second predetermined time period, the presence of a bar code symbol on said object in said scan field on the basis of one of said analog and digital signals, and generating said bar code presence indication signal; and

symbol decoding means for processing said digital data signal and producing symbol character data upon decoding said digital data signal, said processing and producing occurring during and for not more than said second predetermined time period, and said produced symbol character data corresponding to said decoded bar code symbol.

36. The automatic bar code symbol reading system of Claim 36, wherein said bar code presence detection means comprises signal processing means for processing, during and for not more than said second predetermined time period, one of said analog and digital signals and generating said bar code presence indication signal upon determination that the reflected light of variable intensity represents a spatial variation of light reflectivity indicative of the presence of a bar code symbol on said object in said scan field.

37. The automatic bar code symbol reading system of Claim 37, wherein said signal processing means comprises bar code detection means for detecting the presence of a bar code symbol in said scan field by detecting reflected light of variable intensity indicative of the envelope of a bar code symbol.

38. The automatic bar code symbol reading system of Claim 38, which further includes hand-holdable housing for containing said object detecting means, said scanning means, said photoreceiving means, said analog-to-digital conversion means, said signal processing means and said symbol decoding means.

39. The automatic bar code symbol reading system of Claim 39, wherein said object detecting means comprises: illumination means for illumination of at least a portion of said scan field with an illumination signal and detection means for detecting a return signal produced by reflection of said illumination signal off of said object in said scan field, whereupon said activation signal is generated.

40. The automatic bar code symbol reading system of Claim 36, wherein said object detecting means comprises: ambient light detection means for detecting changes in ambient light levels within said scan field as said object is moved therewithin, whereupon said activation signal is generated.

41. The automatic bar code symbol reading system of Claim 36, wherein further comprises data format conversion means for converting said symbol character data to a data format.

42. The automatic bar code symbol reading system of Claim 42, which further comprises a data transmission means capable of receiving format converted symbol character data from said data format conversion means and transmitting said format converted symbol character data to said host system.

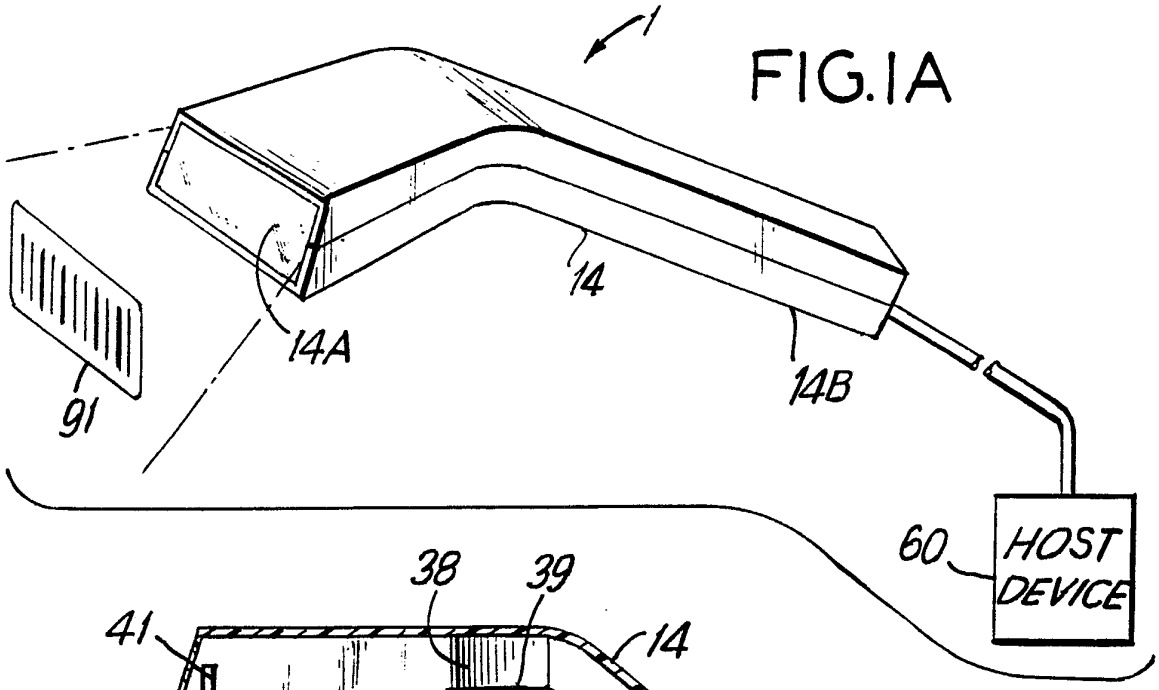


FIG.1A

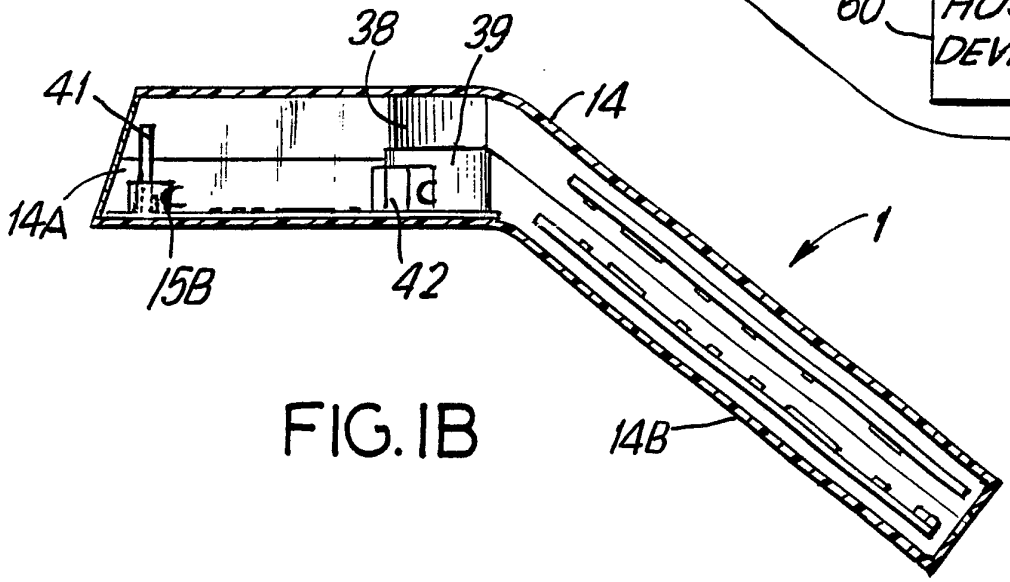


FIG.1B

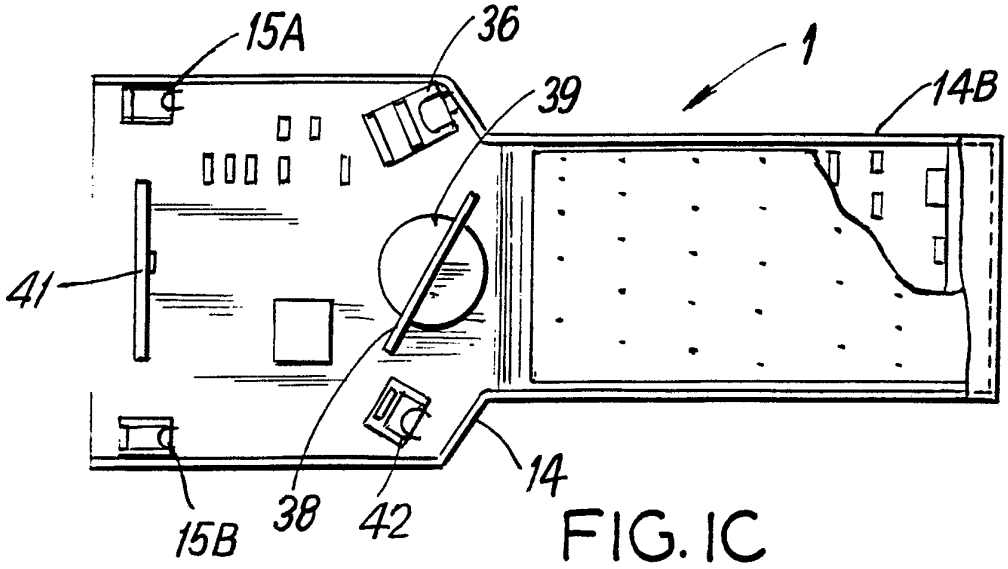


FIG.1C

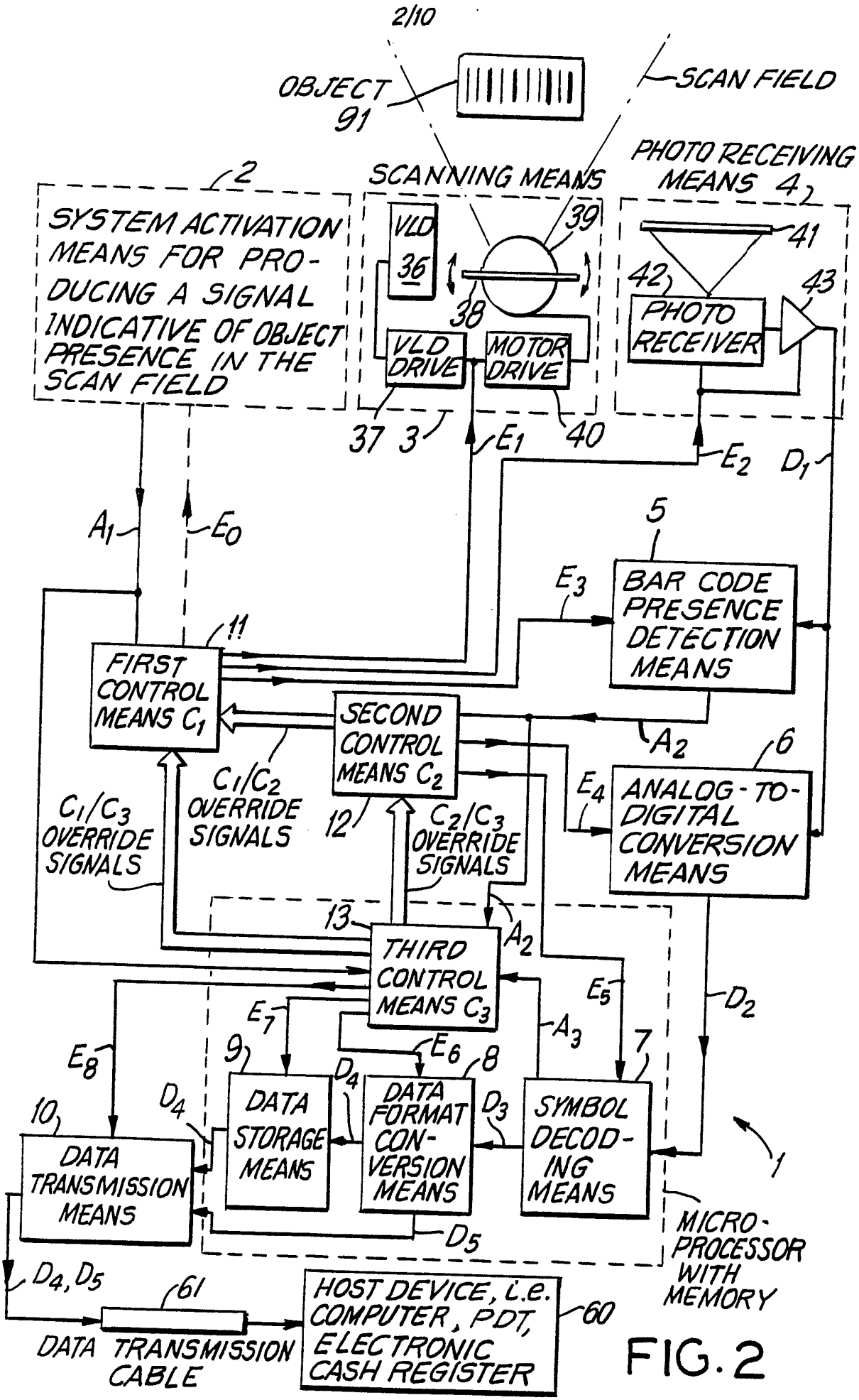

2/10
OBJECT 91
SCAN FIELD
PHOTO RECEIVING MEANS 4
SCANNING MEANS
2
SYSTEM ACTIVATION MEANS FOR PRODUCING A SIGNAL INDICATIVE OF OBJECT PRESENCE IN THE SCAN FIELD
VLD 36
39
41
42
43
38
PHOTO RECEIVER
VLD DRIVE
MOTOR DRIVE
37
3
40
E_1
E_2
D_1
A_1
E_0
5
E_3
BAR CODE PRESENCE DETECTION MEANS
11
FIRST CONTROL MEANS C_1
SECOND CONTROL MEANS C_2
A_2
6
E_4
ANALOG-TO-DIGITAL CONVERSION MEANS
C_1/C_3 OVERRIDE SIGNALS
C_1/C_2 OVERRIDE SIGNALS
12
C_2/C_3 OVERRIDE SIGNALS
13
THIRD CONTROL MEANS C_3
A_2
E_5
D_2
E_7
A_3
E_6
E_8
9
8
7
D_4
D_3
10
D_4
DATA STORAGE MEANS
DATA FORMAT CONVERSION MEANS
SYMBOL DECODING MEANS
DATA TRANSMISSION MEANS
1
D_5
MICRO-PROCESSOR WITH MEMORY
D_4, D_5
61
HOST DEVICE, i.e. COMPUTER, PDT, ELECTRONIC CASH REGISTER
60
DATA TRANSMISSION CABLE

FIG. 2

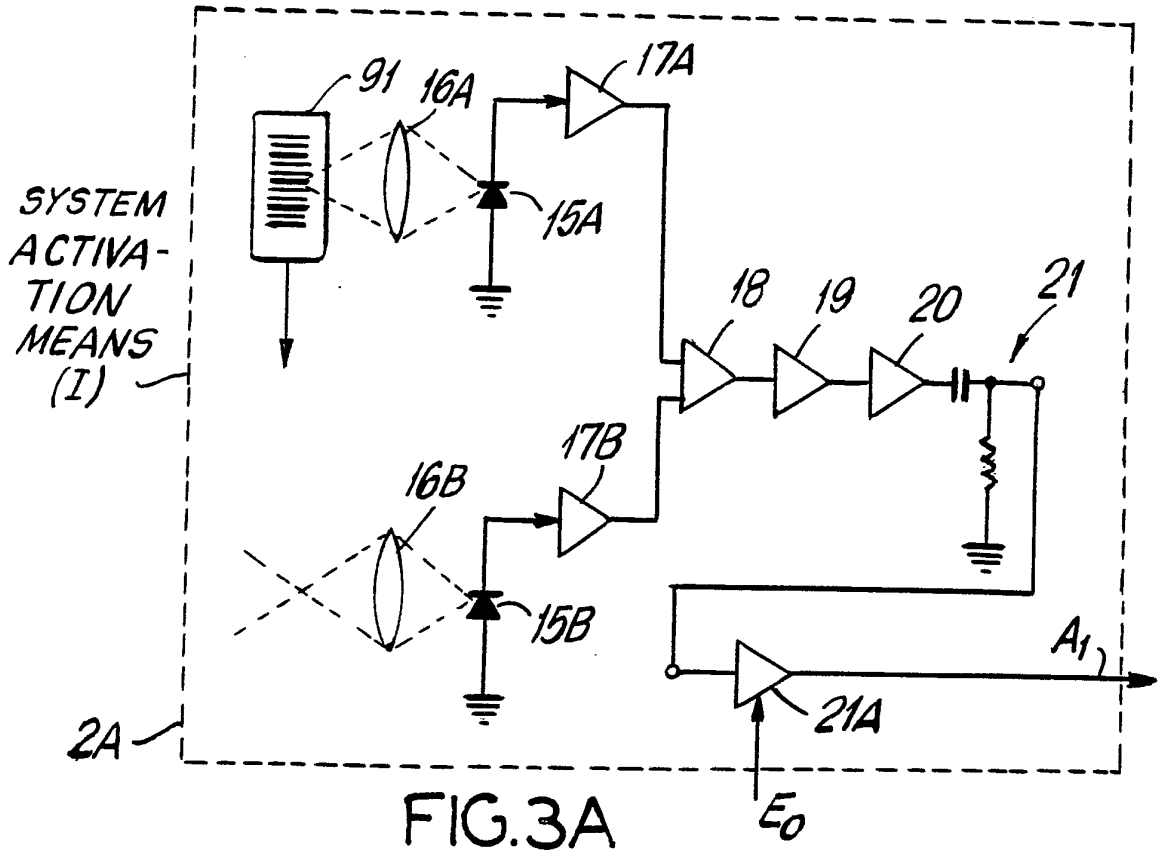

SYSTEM ACTIVA-TION MEANS (I)
91
16A
17A
15A
18
19
20
21
17B
16B
15B
A1
21A
2A
Eo

FIG.3A

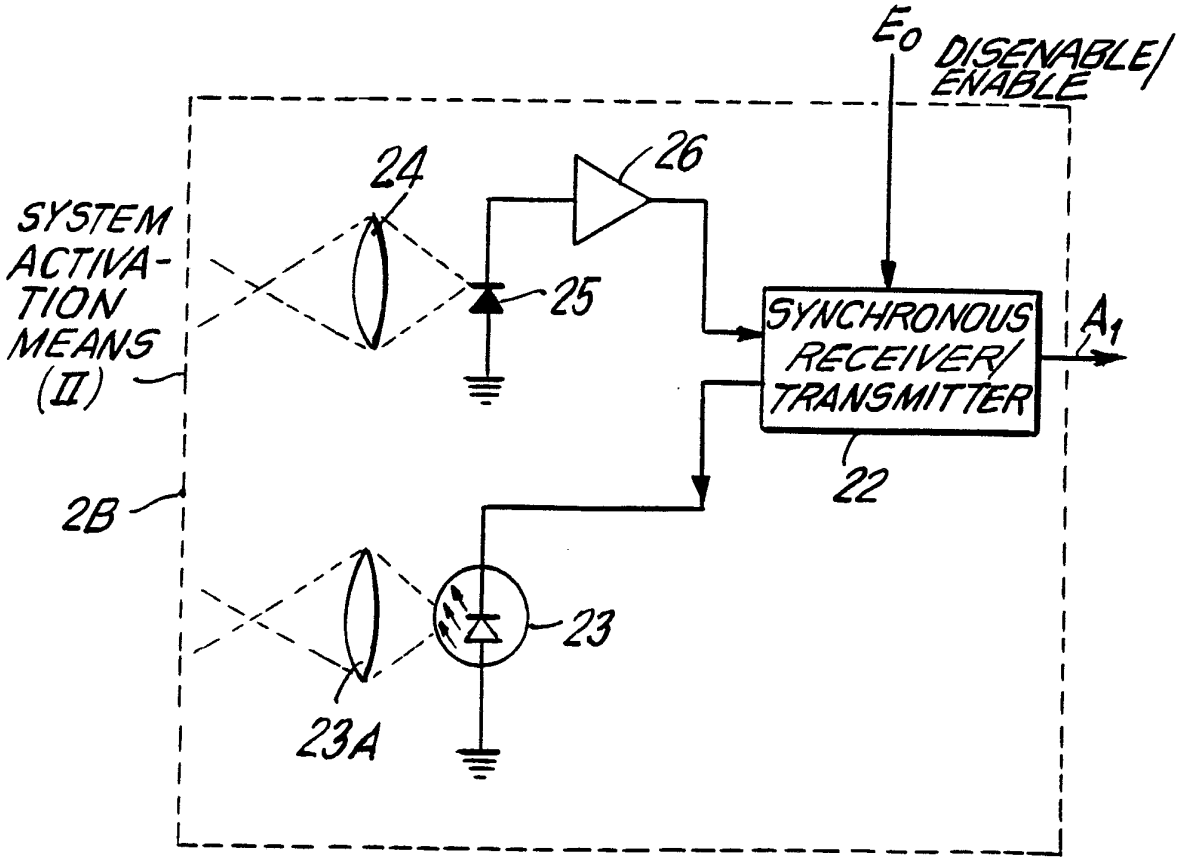

Eo
DISENABLE/ ENABLE
SYSTEM ACTIVA-TION MEANS (II)
24
26
25
SYNCHRONOUS RECEIVER/ TRANSMITTER
A1
22
2B
23
23A

FIG.3B

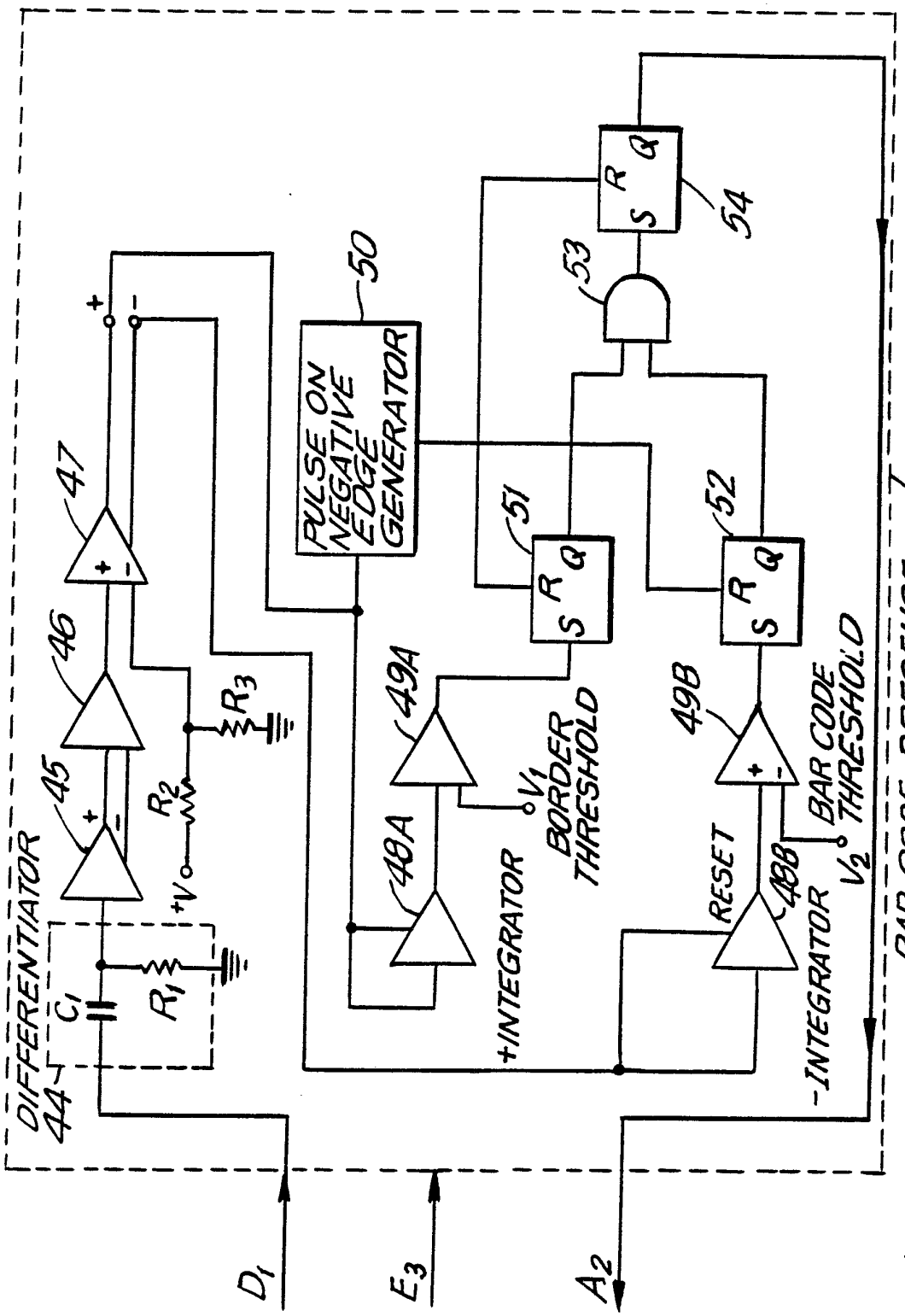

DIFFERENTIATOR
44
C1
R1
45
46
47
R2
R3
+V
PULSE ON NEGATIVE EDGE GENERATOR
50
51
52
53
54
49A
48A
+INTEGRATOR
V1 BORDER THRESHOLD
49B
48B
-INTEGRATOR
RESET
V2 BAR CODE THRESHOLD
BAR CODE PRESENCE DETECTION MEANS
5
D1
E3
A2

FIG. 4

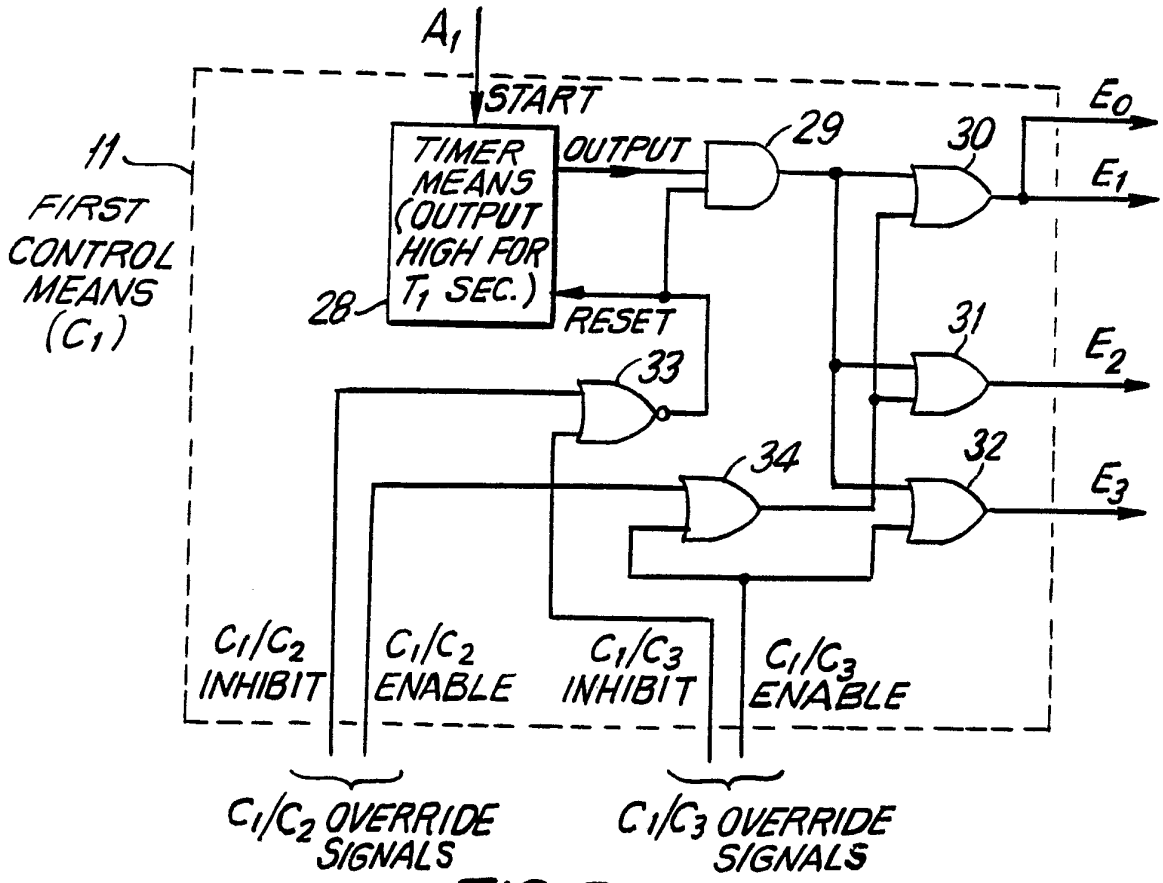

A1
START
11
FIRST CONTROL MEANS (C1)
TIMER MEANS (OUTPUT HIGH FOR T1 SEC.)
28
OUTPUT
RESET
29
30
31
32
33
34
E0
E1
E2
E3
C1/C2 INHIBIT
C1/C2 ENABLE
C1/C3 INHIBIT
C1/C3 ENABLE
C1/C2 OVERRIDE SIGNALS
C1/C3 OVERRIDE SIGNALS

FIG.5

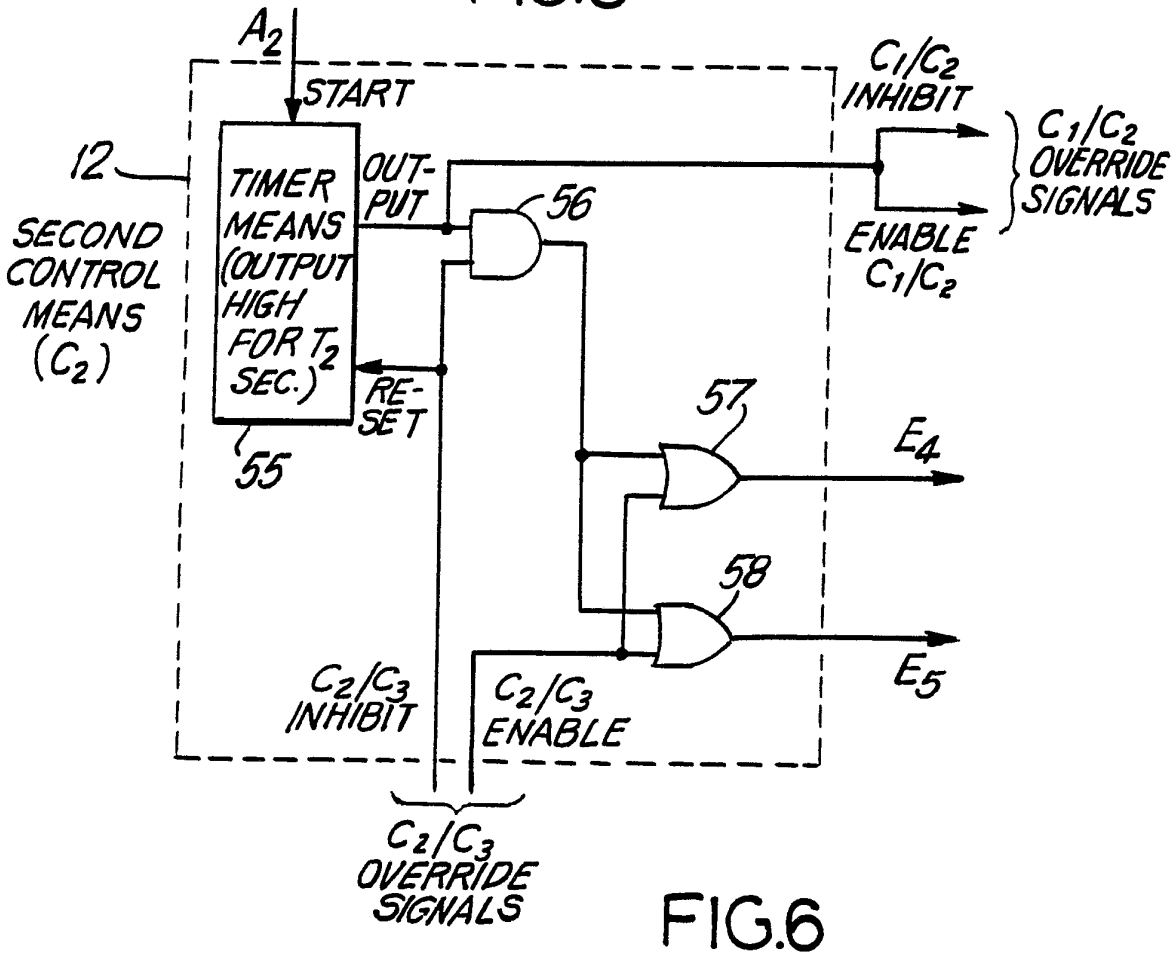

A2
START
12
SECOND CONTROL MEANS (C2)
TIMER MEANS (OUTPUT HIGH FOR T2 SEC.)
55
OUT-PUT
RE-SET
56
57
58
E4
E5
C1/C2 INHIBIT
C1/C2 OVERRIDE SIGNALS
ENABLE C1/C2
C2/C3 INHIBIT
C2/C3 ENABLE
C2/C3 OVERRIDE SIGNALS

FIG.6

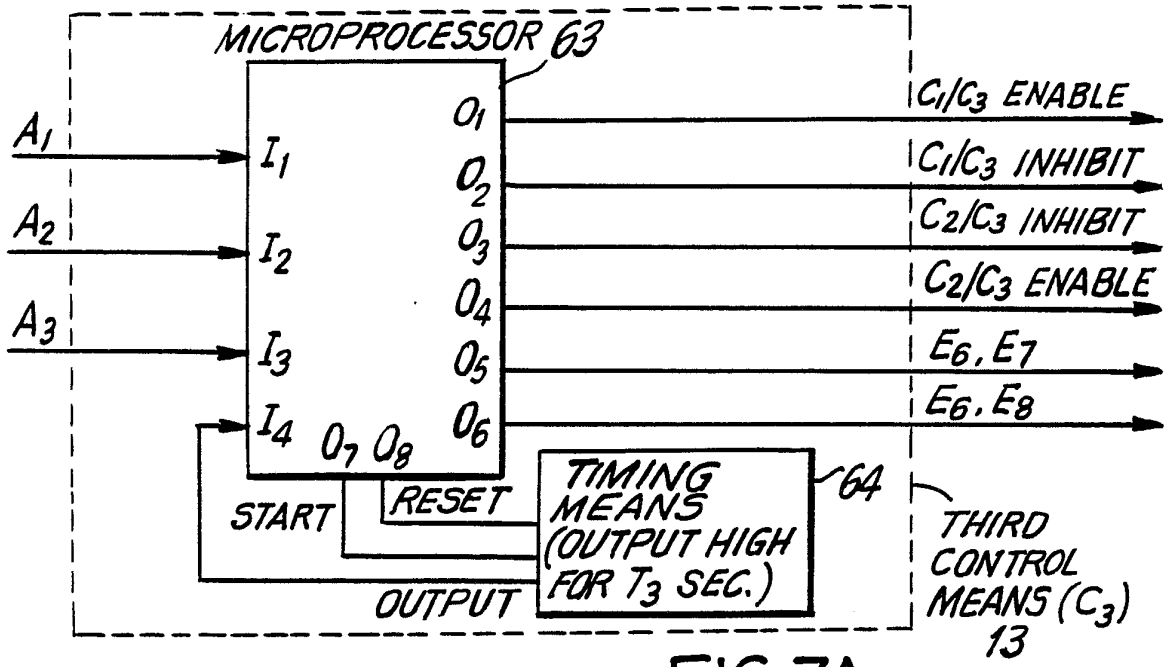

MICROPROCESSOR 63
A1
A2
A3
I1
I2
I3
I4
O7 O8
O1
O2
O3
O4
O5
O6
C1/C3 ENABLE
C1/C3 INHIBIT
C2/C3 INHIBIT
C2/C3 ENABLE
E6, E7
E6, E8
START
RESET
OUTPUT
TIMING MEANS (OUTPUT HIGH FOR T3 SEC.)
64
THIRD CONTROL MEANS (C3) 13

FIG.7A

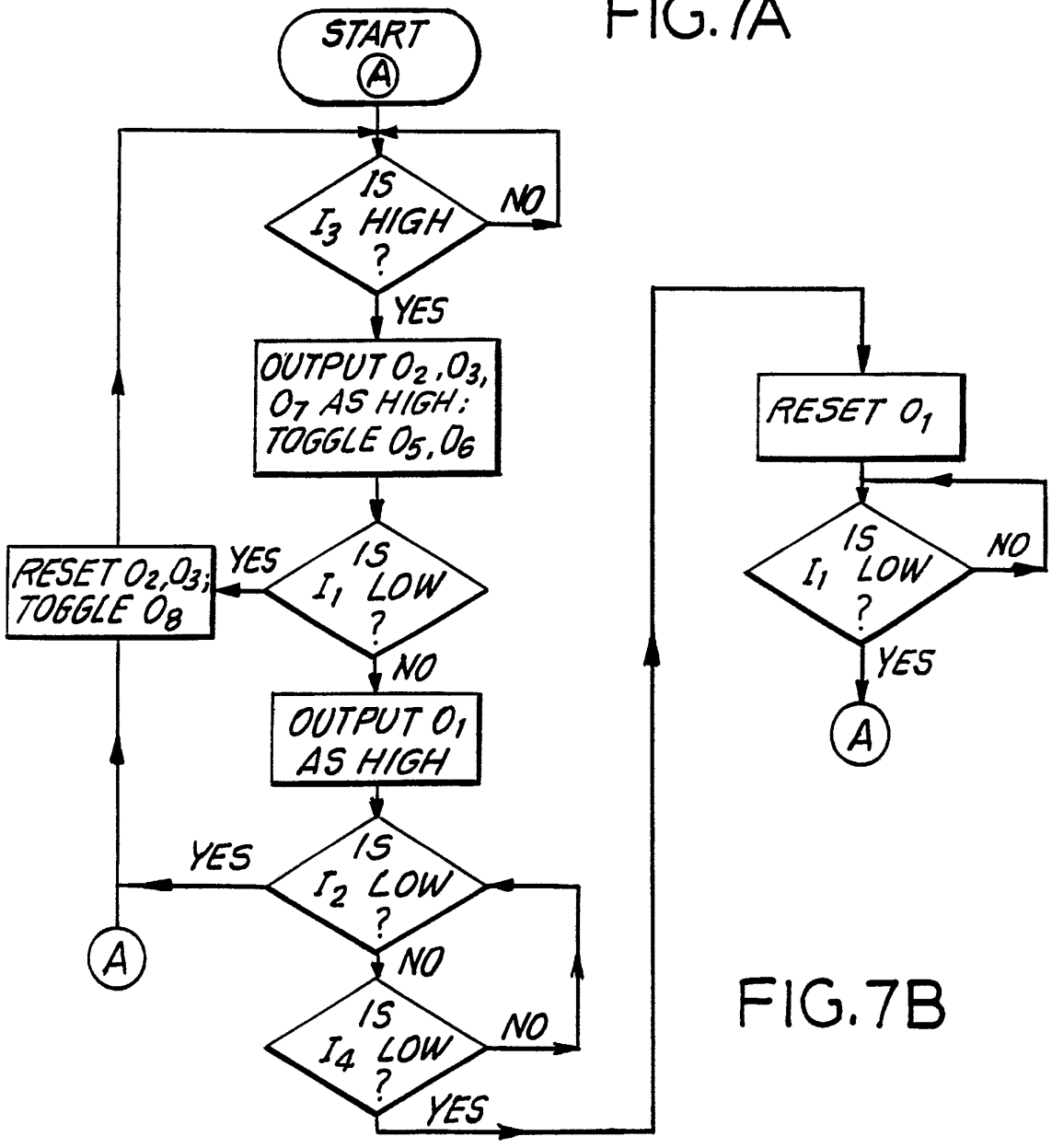

START
A
IS I3 HIGH ?
NO
YES
OUTPUT O2, O3, O7 AS HIGH; TOGGLE O5, O6
IS I1 LOW ?
YES
RESET O2, O3; TOGGLE O8
NO
OUTPUT O1 AS HIGH
IS I2 LOW ?
YES
A
NO
IS I4 LOW ?
NO
YES
RESET O1
IS I1 LOW ?
NO
YES
A

FIG.7B

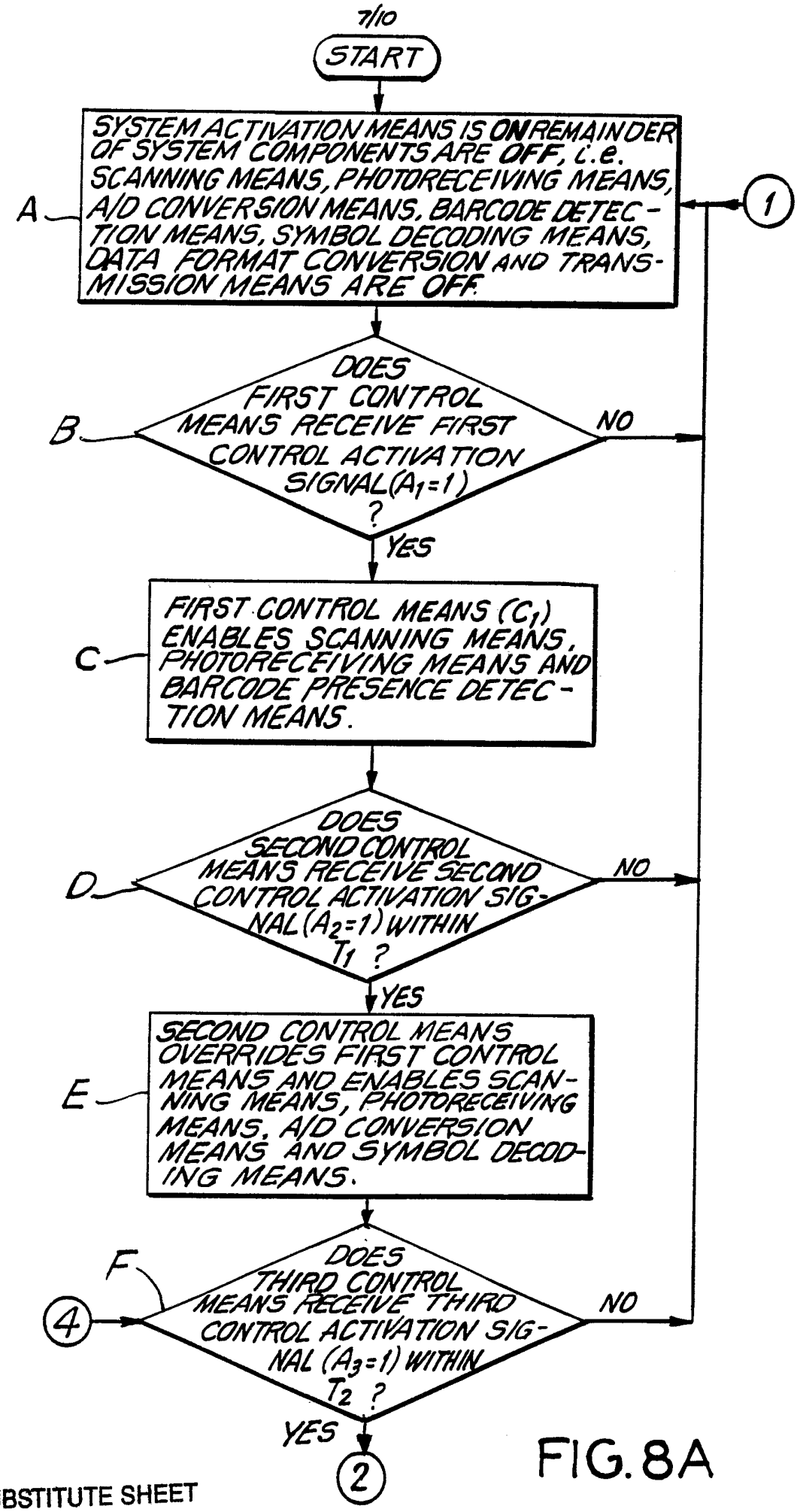

START
SYSTEM ACTIVATION MEANS IS ON REMAINDER OF SYSTEM COMPONENTS ARE OFF, i.e. SCANNING MEANS, PHOTORECEIVING MEANS, A/D CONVERSION MEANS, BARCODE DETECTION MEANS, SYMBOL DECODING MEANS, DATA FORMAT CONVERSION AND TRANSMISSION MEANS ARE OFF.
A
1
DOES FIRST CONTROL MEANS RECEIVE FIRST CONTROL ACTIVATION SIGNAL ($A_1=1$) ?
B
NO
YES
FIRST CONTROL MEANS (C_1) ENABLES SCANNING MEANS, PHOTORECEIVING MEANS AND BARCODE PRESENCE DETECTION MEANS.
C
DOES SECOND CONTROL MEANS RECEIVE SECOND CONTROL ACTIVATION SIGNAL ($A_2=1$) WITHIN T_1 ?
D
NO
YES
SECOND CONTROL MEANS OVERRIDES FIRST CONTROL MEANS AND ENABLES SCANNING MEANS, PHOTORECEIVING MEANS, A/D CONVERSION MEANS AND SYMBOL DECODING MEANS.
E
DOES THIRD CONTROL MEANS RECEIVE THIRD CONTROL ACTIVATION SIGNAL ($A_3=1$) WITHIN T_2 ?
F
4
NO
YES
2

FIG. 8A

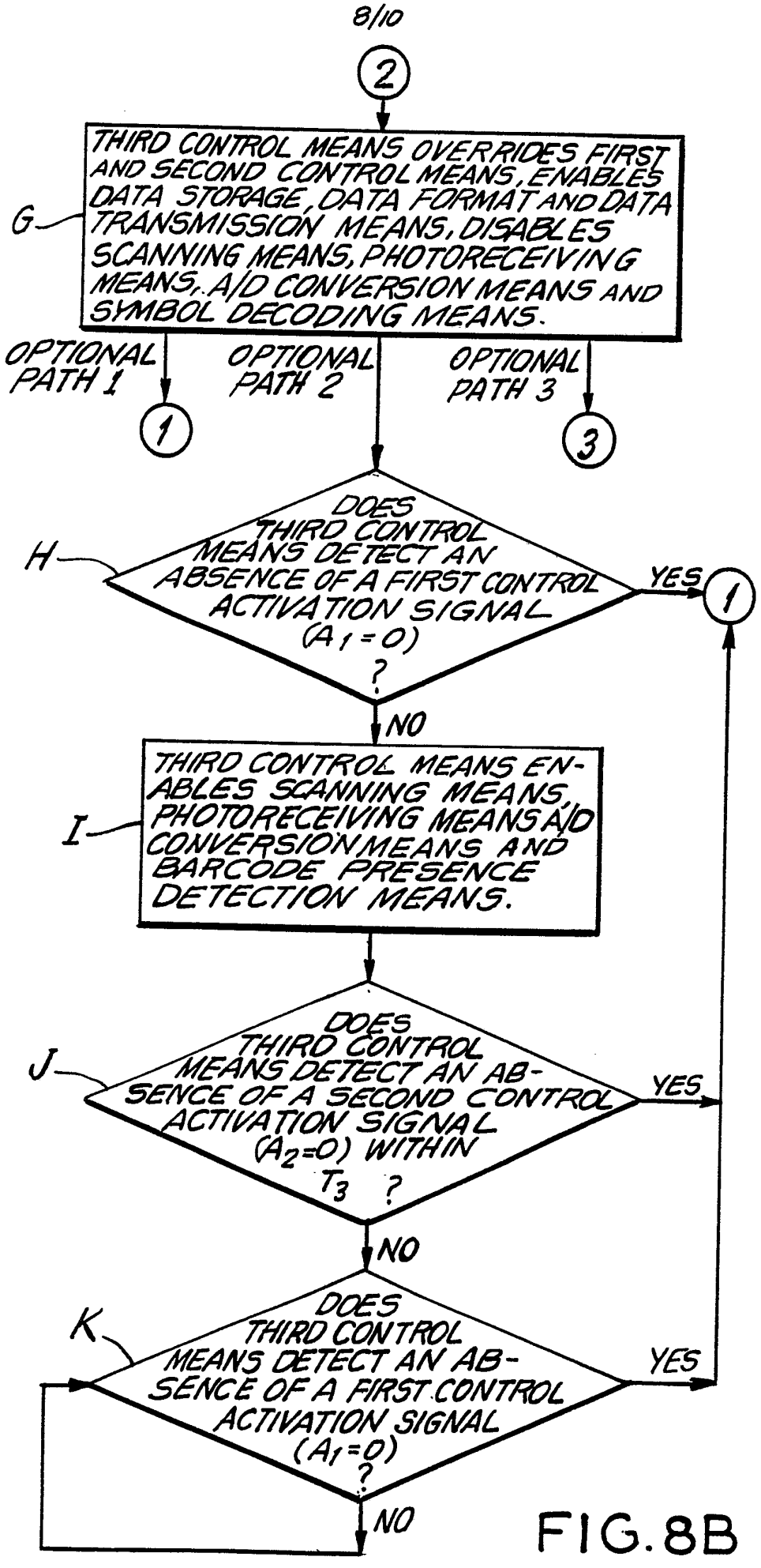

2
THIRD CONTROL MEANS OVERRIDES FIRST AND SECOND CONTROL MEANS, ENABLES DATA STORAGE, DATA FORMAT AND DATA TRANSMISSION MEANS, DISABLES SCANNING MEANS, PHOTORECEIVING MEANS, A/D CONVERSION MEANS AND SYMBOL DECODING MEANS.
G
OPTIONAL PATH 1
OPTIONAL PATH 2
OPTIONAL PATH 3
1
3
DOES THIRD CONTROL MEANS DETECT AN ABSENCE OF A FIRST CONTROL ACTIVATION SIGNAL ($A_1 = 0$) ?
H
YES
1
NO
THIRD CONTROL MEANS ENABLES SCANNING MEANS, PHOTORECEIVING MEANS A/D CONVERSION MEANS AND BARCODE PRESENCE DETECTION MEANS.
I
DOES THIRD CONTROL MEANS DETECT AN ABSENCE OF A SECOND CONTROL ACTIVATION SIGNAL ($A_2 = 0$) WITHIN T_3 ?
J
YES
NO
DOES THIRD CONTROL MEANS DETECT AN ABSENCE OF A FIRST CONTROL ACTIVATION SIGNAL ($A_1 = 0$) ?
K
YES
NO

FIG. 8B

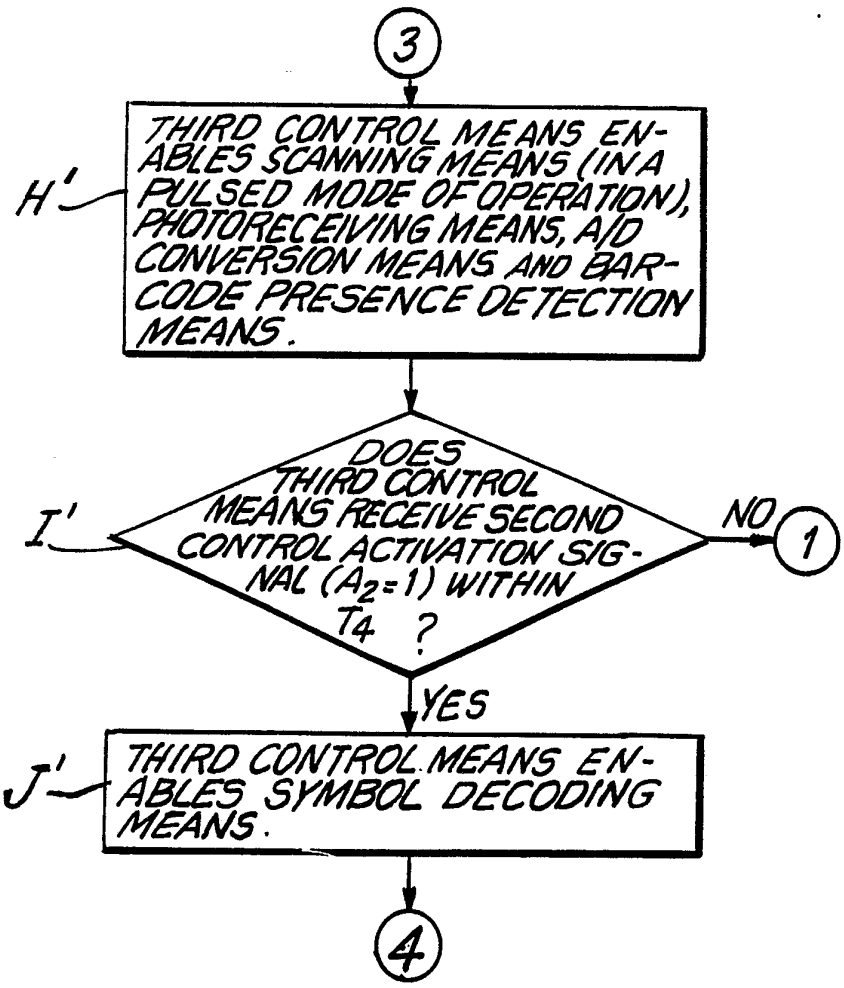

3
H'
THIRD CONTROL MEANS ENABLES SCANNING MEANS (IN A PULSED MODE OF OPERATION), PHOTORECEIVING MEANS, A/D CONVERSION MEANS AND BAR-CODE PRESENCE DETECTION MEANS.
I'
DOES THIRD CONTROL MEANS RECEIVE SECOND CONTROL ACTIVATION SIGNAL (A_2=1) WITHIN T_4 ?
NO
1
YES
J'
THIRD CONTROL MEANS ENABLES SYMBOL DECODING MEANS.
4

FIG. 8C

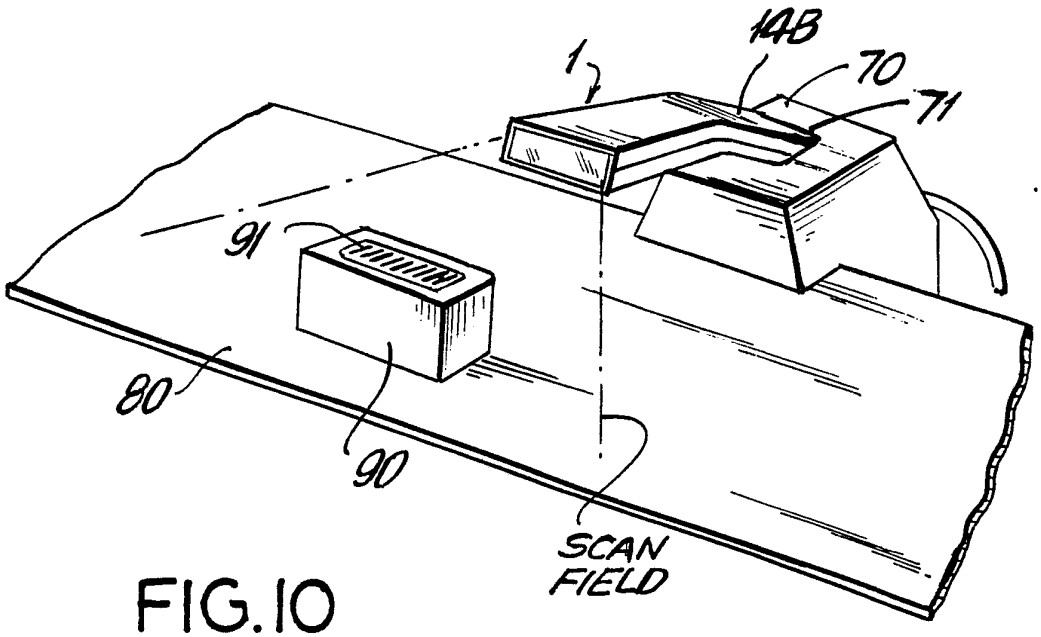

14B
1
70
71
91
80
90
SCAN FIELD

FIG. 10

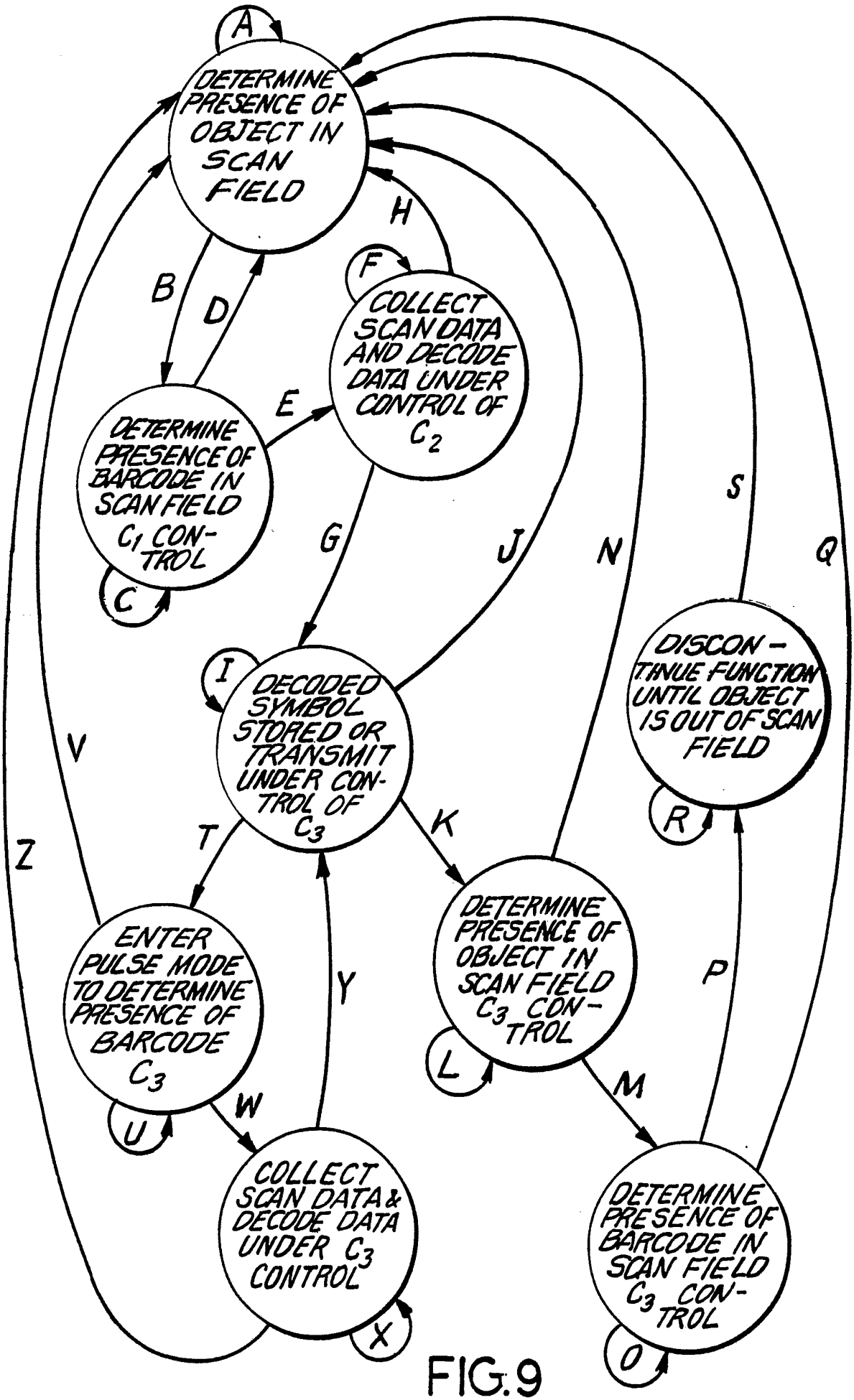


FIG. 9

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/06608

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): G06K 7/10; G06K 9/00
U.S. CL.: 235/462; 235/455

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	235/383,438,455,462,463,466,470,472

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 4,240,064 (DevCHAUDHURY) 16 December 1980. See the Abstract and Fig. 1.	1,12,18,27,35
Y	US, A, 4,101,072 (WEAVER ET AL.) 18 July 1978. See the Abstract, Figs, 3 and 6, Col. 2 Line 65 to Col. 4 Line 22.	1,4,5,12,18, 27,35
Y	US, A, 4,431,912 (DICKSON ET AL.) 14 February 1984. See the Abstract, Fig. 1.	1,7,12,18, 27,35
Y	US, A, 4,766,297 (McMILLAN) 23 August 1988. See the Abstract, Figs. 1 and 3-4.	1,7,12,18, 27,35
Y	US, A, 4,933,538 (HEIMAN ET AL.) 12 June 1990. See Fig. 1 and Col. 2 Line 56 to Col. 3 Line 7.	1,4,7,12,18, 27,35
Y	US, A, 4,639,606 (BOLES ET AL.) 27 January 1987. See the Abstract and Figs. 1 and 3-5.	1,4,7,12,18, 27,35

* Special categories of cited documents: [10]

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

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search: 19 DECEMBER 1991

Date of Mailing of this International Search Report: 27 DEC 1991

International Searching Authority: ISA/US

Signature of Authorized Officer: ROBERT WEINHARDT