646439

P/00/001
Section 29

AUSTRALIA
Patents Act 1990
PATENT REQUEST : STANDARD PATENT

We, being the person(s) identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Applicant: **FMC CORPORATION**
Address: Executive Offices Patent Department 200 East Randolph Drive, Chicago, Illinois 60601, United States of America

Nominated Person: As above
Address: As above

Invention Title: **HIGH RESOLUTION CAMERA WITH HARDWARE DATA COMPACTION**

Name of Actual Inventor/s: Randy K. BAIRD, of Rd#1, Box 232, Bolivar, Pennsylvania 15932, United States of America; Stanley P. TURCHECK Jr., of Rd#3, Box 1105, Homer City, Pennsylvania 15748, United States of America, and James P. MARTIN, of 103-1/2 Maple Avenue, Blairsville, Pennsylvania 15717, United States of America

Address for service in Australia: CARTER SMITH & BEADLE
Qantas House
2 Railway Parade
Camberwell Victoria 3124
Attorney Code SA

BASIC CONVENTION APPLICATION DETAILS
Application Number: 07/586,189
Country: United States of America
Code: US
Date of Application: 21st September, 1990

M 029702 290991

Dated this 27th day of August, 1991.

CARTER SMITH & BEADLE
Patent Attorneys for the Applicant

Our Ref: #8454 TNB:WB 08-7fmc

PATENT DECLARATION FORM
(CONVENTION OR NON-CONVENTION)

In support of the application made by FMC CORPORATION, a Delaware corporation, United States of America, with executive offices at 200 East Randolph Drive, Chicago, Illinois 60601, United States of America, for a patent for an invention entitled:

HIGH RESOLUTION CAMERA WITH HARDWARE DATA COMPACTION

I, RICHARD B. MEGLEY, of 200 East Randolph Drive, Chicago, Illinois 60601-0000 United States of America, do solemnly and sincerely declare as follows:

1. I am authorized by the abovementioned applicant to make this declaration on its behalf.

2. Randy K. Baird, Stanley P. Turcheck, Jr. and James P. Martin, citizens of the United States of America, Rd#1, Box 232, Bolivar, Pennsylvania 15932; Rd#3, Box 1105, Homer City, Pennsylvania 15748; and 103-1/2 Maple Avenue, Blairsville, Pennsylvania 15717; United States of America

is/are the actual inventor(s) of the invention and the facts upon which the applicant(s) is/are entitled to make the application are as follows:

Applicant is the assignee of the inventor(s) named in Paragraph 2 by virtue of an Assignment dated 27 June 1991.

3. The basic application(s) as defined by Section 141 of the Act was/were made in the following country on the following date by the following applicant(s):

in the United States of America on 21 September 1990, under Serial No. 07/586,189 by Randy K. Baird, Stanley P. Turcheck, Jr. and James P. Martin

4. The basic application(s) referred to in paragraph 3 of this Declaration was/were the first application(s) made in a Convention country in respect of the invention the subject of the application.

Declared at Chicago, Illinois, United States of America, this 15th day of July, 1991

FMC CORPORATION

By [signature]
Richard B. Megley
Assistant Secretary

NO ATTESTION
OR SEAL

CARTER SMITH & BEADLE, Qantas House, 2 Railway Parade, Camberwell, Victoria 3124, AUSTRALIA

AU9183438

(12) PATENT ABRIDGMENT (11) Document No. AU-B-83438/91
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 646489

(54) Title
HIGH RESOLUTION CAMERA WITH HARDWARE DATA COMPACTION

International Patent Classification(s)
(51)[5] G06F 015/70

(21) Application No. : 83438/91 (22) Application Date : 28.08.91

(30) Priority Data

(31) Number 586189 (32) Date 21.09.90 (33) Country US UNITED STATES OF AMERICA

(43) Publication Date : 26.03.92

(44) Publication Date of Accepted Application : 24.02.94

(71) Applicant(s)
FMC CORPORATION

(72) Inventor(s)
RANDY K. BAIRD; STANLEY P. TURCHECK JR.; JAMES P. MARTIN

(74) Attorney or Agent
CARTER SMITH & BEADLE , Qantas House, 2 Railway Parade, CAMBERWELL VIC 3124

(56) Prior Art Documents
US 4977504
US 4974261
US 4833722

(57) Claim

1. A method for compacting serial binary bit stream information for reducing image processing time and memory requirements comprising:

producing a serial bit stream during a scan interval, the bit stream having at least 1000 bits and a number of binary transitions that is no greater than ten percent (10%) of the number of bits;

converting each transition into an edge pulse having a duration less than the duration of one of said bits;

counting bit periods to produce a unique count value for each bit; and

storing only a unique count value for each transition in a memory that is gated on by said edge pulses.

10. A system for storing information related to an orientation of an object moved by a conveyor in a first direction in a memory circuit connected to receive a plurality of digital signals related to a series of adjacent points on at least one marginal edge of said object comprising:

an analog to digital conversion circuit;

a single linear array of charge coupled devices comprising a plurality of pixels

.../2

that extend along a second direction that is transverse to the first direction;

a synchronization circuit including means for producing clock signals;

scanning means for producing an analog voltage signal from said pixels operating in synchronization with said clock signals;

means for outputting said analog voltage signal from said pixels to said analog to digital conversion circuit;

an object edge detection circuit coupled to receive output signals from said analog to digital conversion circuit for generating a transfer signal at a time during a scan of the pixels that is related to detection of an object edge point;

a counter circuit operating in synchronization with said clock signals and said scanning means and being reset between successive scans; and

means connecting said memory circuit to receive a count value from said counter circuit which coincides with the time of occurrence of said transfer signals whereby the count value is the only information stored concerning the location of said object edge points.

15. A system for determining a silhouette of an object moving on a conveyor in a first direction comprising:

at least 1000 pixels aligned in a linear array in a direction transverse to the moving direction of the object to extend above and below the object on the conveyor;

scanning means for successively producing an analog signal voltage from each of said pixels which signal is applied to an analog to digital conversion circuit;

means for generating a transfer signal connected to the output of said analog to digital conversion circuit;

a counter circuit operating in synchronization with said scanning means and at a counting speed in excess of 1 MHz;

a memory connected to said counting circuit to receive a count value only in response to receipt of a transfer signal whereby the difference between two count values obtained during a single scan is related to a dimension of that portion of the object imaged by said pixels.

646489

P/00/0011
Regulation 3.2

AUSTRALIA
Patents Act 1990

COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

Name of Applicant: FMC CORPORATION

Actual Inventor(s): Randy K. BAIRD, Stanley P. TURCHECK Jr., and James P. MARTIN

Address for service in Australia: CARTER SMITH & BEADLE
Qantas House
2 Railway Parade
Camberwell Victoria 3124
Australia
Attorney Code SA

Invention Title: **HIGH RESOLUTION CAMERA WITH HARDWARE DATA COMPACTION**

The following statement is a full description of this invention, including the best method of performing it known to us:

Our Ref: #8454 TNB:WB 08-7fmc

This invention relates to the compaction of data by use of hardware in connection with the real–time creation of a high resolution silhouette image of an object on a moving conveyor.

Background Information

In the inspection by video equipment of objects being transported on a conveyor, it is required that the image processing be done on a real time basis to produce the necessary secondary control signals. Various prior art techniques are disclosed in Ohyama U.S. Patent No. 4,866,783.

Composite video signals are not required for some applications. It may be sufficient to have a high resolution silhouette of an object elevation to determine the object orientation or size. Real time processing of large amounts of data is prohibitive for a feasible low–cost system due to the processing time involved and hugh memory requirements to store all the information customarily used. Usual solutions to enable high resolution would be to invest in an expensive faster computer and to add on the required memory.

Summary of Invention

The invention provides a method for compacting serial binary bit stream information for reducing image processing time and memory requirements comprising:

producing a serial bit stream during a scan interval, the bit stream having at least 1000 bits and a number of binary transitions that is no greater than ten percent (10%) of the number of bits;

converting each transition into an edge pulse having a duration less than the duration of one of said bits;

counting bit periods to produce a unique count value for each bit; and

storing only a unique count value for each transition in a memory that is gated on by said edge pulses.

The invention further provides a system for determining the position of adjacent points lying along an object edge comprising:

an analog to digital conversion circuit including means to control the amplitude level for digital transition;

means for successively scanning a visual image in one direction of an object to transfer an analog information signal relating to an edge point on said object to said analog to digital conversion circuit to produce a pulse related to a location of said object edge point;

a counter circuit synchronized with said scanning means;

means connecting said analog to digital conversion circuit to a transition detection circuit in order to transfer said pulse to trigger count information from said counter circuit that identifies a location of different ones of said object edge points in successive scans;

a first in, first out buffer memory; and

means for applying to said buffer memory count information limited to that which corresponds to said object edge points based on successive scan information thereby to provide object profile data.

The invention still further provides a system for storing information related to an orientation of an object moved by a conveyor in a first direction in a memory circuit connected to receive a plurality of digital signals related to a series of adjacent points on at least one marginal edge of said object comprising:

an analog to digital conversion circuit;

a single linear array of charge coupled devices comprising a plurality of pixels that extend along a second direction that is transverse to the first direction;

a synchronization circuit including means for producing clock signals;

scanning means for producing an analog voltage signal from said pixels operating in synchronization with said clock signals;

means for outputting said analog voltage signal from said pixels to said analog to digital conversion circuit;

an object edge detection circuit coupled to receive output signals from said analog to digital conversion circuit for generating a transfer signal at a time during a scan of the pixels that is related to detection of an object edge point;

a counter circuit operating in synchronization with said clock signals and said scanning means and being reset between successive scans; and

means connecting said memory circuit to receive a count value from said counter circuit which coincides with the time of occurrence of said transfer signals whereby the count value is the only information stored concerning the location of said object edge points.

The invention also provides a system for determining a silhouette of an object moving on a conveyor in a first direction comprising:

at least 1000 pixels aligned in a linear array in a direction transverse to the moving direction of the object to extend above and below the object on the conveyor;

scanning means for successively producing an analog signal voltage from each of said pixels which signal is applied to an analog to digital conversion circuit;

means for generating a transfer signal connected to the output of said analog to digital conversion circuit;

a counter circuit operating in synchronization with said scanning means and at a counting speed in excess of 1 MHz;

a memory connected to said counting circuit to receive a count value only in response to receipt of a transfer signal whereby the difference between two count values obtained during a single scan is related to a dimension of that portion of the object imaged by said pixels.

The objects and advantages of the invention will become more fully apparent from the claims, and from the description as it proceeds in conjunction with the drawings.

Brief Description of Drawings

Fig. 1 is a diagrammatic view of a conveyor system for separating and orienting parts, together with a novel inspection camera and information processor;

Fig. 2 is a block diagram of a camera sensor and related functional circuitry for acquiring and storing object silhouette information;

Fig. 3 is an elevation of a conveyor moving surface that is supporting a round of ammunition;

Fig. 4 is a group of waveforms taken at scan position 120 as depicted by line 4-4 of Fig. 3;

Fig. 5 is a group of waveforms taken at scan position 800 as depicted by line 5-5 of Fig. 3;

Fig. 6 is a diagram of a suitable circuit arrangement for hardware that can compact the object image intelligence data.

<u>Detailed Description of Preferred Embodiment</u>

The present embodiment ~~invention~~ is adapted for use with conveyors that move a series of like objects on a repetitive basis for automated inspection or assembly. The invention serves as a substitute for human inspection of the object orientation on the conveyor surface and is adapted to provide data representation concerning a part size that may have a resolution as little as 0.0005 inches.

In the illustrated conveyor 10 of Fig. 1, objects 12, 14, 16 rest on a surface 18 that moves in a counter-clockwise direction while a tilted central disk rotates at a slower speed to load objects in spaced positions along conveyor surface 18 in a known manner. The objects 12, 14, 16 pass between a camera sensor 22 and a light source 24 after which they move downstream to a conventional detector 26 and diverter 28 which enables reorientation and/or rejection or improperly oriented or sized articles. The diverter may of the general type as shown in Dean et al U.S. Patent No. 4,619,356.

In accord with one preferred feature of the present invention, a camera sensor 22 is not a raster scan type, but instead consists of a linear array of charge coupled device (CCD) units. The CCD units are aligned to be transverse to the direction of object movement. The linear array of CCD units thus may be essentially vertical in the case of a horizontal conveyor. The CCD units are aligned in a single column that is one pixel wide and at least about 1000 pixels high. The height of the CCD unit column must be sufficient to span the feature of interest of the object 12, 14, 16 on the conveyor 18. For many small objects such as bolts, screwdriver handles, small caliber ammunition and the like, a maximum variation of the feature of interest may be within a one inch span.

A silhouette image data obtained for certain applications must have a 0.0025 inch resolution. The number of CCD units in the one inch column may conveniently be about 2000 and advantageously may be 2048. An even smaller resolution below 0.0005 inches may be obtained with the use of about 3000 or 4000 pixels in a one inch column. The linear array of CCD units may be obtained commercially from Texas Instruments as TC-103-1. The drive circuitry necessary for proper CCD operation and timing diagrams to provide a sequential scan of the analog voltage signal are commercially available. The scan rate must provide sufficient time to transfer each pixel charge fully and not allow any charge to accumulate in pixel between reset and the next scan at which time a momentary voltage is applied to each of the CCD sensing units.

In the preferred system of the present invention, the light source 24 is located across the conveyor surface 18 to face the CCD units. As an object 12, 14, 16 passes between the light source 24 and the camera sensor 22, a shadow is formed on certain of the pixel areas whereas unblocked pixels are fully illuminated by the light. By use of a collimated light source which operates through a lens having a shape and size corresponding to that of the linear array of CCD units forming a camera sensor, a precise point on the upper edge surface of the object can be optically determined with great accuracy. Variations in ambient light conditions are less likely to interfere with operation of the camera sensor when a collimated light source is used.

If the object has a point on the lower edge surface that is positioned above the conveyor surface (Fig. 3, line 4-4) a light beam will be detected at appropriately positioned pixels in the same linear array at a point #100 on the lower surface which is opposite the detected point #500 on the upper object surface. Similarly, an aperture in the object which is aligned between collimated light source and the camera sensor will produce transitions in the adjacent pixels to provide a manifestation of the marginal edge points of the aperture at successive positions as the object advances past the camera sensor.

Successive exposures of the camera sensor 22 to the collimated light as each object 12, 14 or 16 moves in sequence along the conveyor path 18 gives successive data inputs which may be sequentially processed and collectively used to provide as a display, a silhouette of each object before the object reaches the diverter station 28. Object speed on the conveyor may be several per second depending upon the desired resolution. Successive scans may be provided at 300 microsecond intervals with a 2048 pixel linear array driven by a 10 MHz clock. Conveyor speeds up to seven inches per second may be acceptable without exceeding the resolution accuracy specified.

The installation as illustrated in Fig. 1 may include also a system control 30 and control box 32 which are usually physically located near the conveyor.

With reference to Fig. 2, a functional block diagram of the camera sensor 22 is illustrated. The vertical column of CCD units 34, consisting of a 2048 pixel linear array in the illustrated embodiment, is connected to receive clocking or timing signals from the clock and sync circuit 35. Clock circuit 35 includes an oscillator running at a frequency of at least about one MHz, and 10 MHz in the illustrated example, in order to provide pixel scanning in about 200 microseconds and 100 microseconds for reset operation. The CCD units that are commercially available are capable of running at clock frequencies as high as 40 MHz. Thus, pixel scan during a 300 microsecond sampling scan after conditioning, is used to produce an analog information signal which contains a transition relating to the precise position of an edge point on an object or part which is being conveyed.

Each panel in the column of CCD units 34 produces an output signal on lead 36 in the form of an analog signal voltage (see Figs. 4 and 5) containing sequentially obtained voltages of a first amplitude for shadowed pixels and a second low amplitude for those pixels receiving light from light source 24. The analog information is a serial bit stream of uniform length and is transferred serially at the clock rate to a voltage follower that serves as an isolation circuit 38 and to a black sample and hold circuit 40 which produces a voltage level reference signal from pixels that are blocked from receiving light. This provides a reference signal which holds the analog signal at a controlled DC level and may be used as one input to circuitry associated with an analog to digital conversion circuit 42.

The output signal on lead 44 is applied to the data compaction unit 48 comprising a transition detector and a data compaction circuitry which will be described in connection with Fig. 6. On lead 46, a clock signal from the clocking and sync circuit 35 is applied to maintain synchronization between the data compaction unit 48 and the scanning means that is part of the charge coupled device array 34.

The output signals from the data compaction device 48 are transmitted on leads 50 to the data buffing memory (FIFO) 52. Each signal is in the form of a single binary number for each transition which the data compaction unit 48 receives on line 44 from the analog to digital conversion circuit A/D 42. The memory unit (FIFO) 52 serves as a buffer to collect all of the data for a particular object 12, 14 or 16 on the conveyor surface on a first in, first out basis. The microprocessor unit 54, which may be any suitable type that is commercially available, may start to process the output signals as soon as the memory 52 begins to receive valid object data.

The camera sensor 22 is thus synchronized with a counter in the data compactor 48 by means of the clocking and sync circuit 35. The memory 52 for data buffering may have a 64K or even smaller capacity for objects of the type mentioned above. As pointed out above, low cost commercially off-shelf available components have a capability to operate up to a 10 MHz data rate in a reliable fashion thereby providing a low cost hardware product.

With reference to Fig. 3, there illustrated a round of ammunition which has a cylindrical cartridge or casing 56 that is supported on a conveyor surface 18 and a projectile 58. Fig. 4 contains a group of waveforms taken along line 4-4 of Fig. 3 and Fig. 5 contains a group of similar waveforms taken along line 5-5 of Fig. 3. Fig. 4 waveforms are taken at a position along line 4-4 on the projectile 58 corresponding to scan 120 whereas, the Fig. 5 waveforms are taken at scan 800 along line 55 on the cartridge shell 56.

In Fig. 4, the waveform of the amplified analog signal starts at time 0 in a black condition because of the conveyor 18. At pixel 30, which corresponds to count 30 in a counter, light is detected thereby starting a negative going digital pulse and a positive going edge detector pulse 60. At pixel 100, the lower edge point on the silhouette of the projectile 58 is effective to block light and create a further edge detector pulse 62. At pixel 500, the light is again detected, thereby causing a third edge detector signal 64 to be generated. Finally, at the top of pixel linear array and pixel 2048, the scanner no longer produces a signal and an end of scan transition detector pulse 66 is generated.

A conventional binary counter capable of counting up to at least 2048 at the clock frequency is synchronized with the scan of the 2048 pixels in the camera sensor as indicated at the bottom waveform of Fig. 4. The clock is reset to start at zero as the scan starts so that count values of 30, 100, 500 and 2048 are stored in the memory 52 of Fig. 2 as determined by the time of occurrence of edge detector pulses 60, 62, 64 and 66.

Fig. 5 shows the corresponding waveforms that occur at scan 800 along 5-5 on the cartridge shell 56. Since the lowest point on the cylindrical casing 56 rests on the conveyor surface 18, the lowest 1499 pixels in the linear array are dark and the first transition occurs with pixel 1500, which is aligned with the upper edge point of the cartridge casing 56 at scan position 800.

The edge detector pulse 68 is generated in response to the transition at pixel 1500 and causes the count value of 1500 to fall through the memory 52 to its output terminals. A similar edge detector pulse 70 occurs at count 2048. Thereafter, a master reset pulse is generated. The counters are reset to a zero count by a counter reset signal which is synchronized with the beginning of the next scan of the pixels.

Fig. 6 shows one preferred embodiment for converting the digital signals of Figs. 4 and 5 into count values that are supplied to the microprocessor unit (MPU) ~~56.~~ 54. The digital signal from Fig. 4, in the form of incoming serial binary bit, is applied to terminal 80 of a negative and positive edge detecting network that detects changes in the binary state and issues for each positive or negative edge a 50n sec. pulse on lead 82. At a 10 MHz clock frequency, the scanned information data and clock counts are separated by 100n sec. The 50n sec. pulse is used to gate on the memory unit 52 (Fig. 2) which includes FIFO registers 84 as illustrated in Fig. 6. The three binary counter registers 86 that operate with clock signals on lead 46 are reset by a counter reset signal on lead 88. The count value on leads 50 is constantly presented to the FIFO registers 84. However, the count values are allowed to drop through the FIFO registers 84 only when an edge detector pulse on lead 82 is present. In this example, the count values of 30, 100, 150 and 2048 are stored.

When a count value falls through the FIFO registers 84, the FIFO issues an output ready signal to MPU 54 on lead 92. When the MPU sees an output ready signal, it issues a shift out signal on lead 94 to FIFO registers 84 which releases the count value immediately to the MPU 90. The data at this point is then coded object image intelligence. This handshaking continues throughout the entire scan cycle and sequentially throughout all scans of a object.

As is evident from the foregoing, for the scan 120, only four count values are processed and stored rather than 2048 bits of scan information. Other scans such as scan 800 may have only two count values that are processed. The number of scans may be decreased where less resolution in the horizontal direction is acceptable thereby further reducing the processing time. This compaction of data increases processing speed and reduces memory size requirements without sacrificing resolution of the silhouette image.

While only a single embodiment has been illustrated, other modifications and variations will become apparent to those skilled in this art. The illustrated embodiment has a degree of sophistication which can be simplified for less demanding applications. It is therefore intended that the variations and modifications which fall within the scope of the appended claims and equivalents thereof be covered thereby.

The claims form part of the disclosure of this specification.

The claims defining the invention are as follows:

1. A method for compacting serial binary bit stream information for reducing image processing time and memory requirements comprising:

producing a serial bit stream during a scan interval, the bit stream having at least 1000 bits and a number of binary transitions that is no greater than ten percent (10%) of the number of bits;

converting each transition into an edge pulse having a duration less than the duration of one of said bits;

counting bit periods to produce a unique count value for each bit; and

storing only a unique count value for each transition in a memory that is gated on by said edge pulses.

2. The method as defined in claim 1 wherein a plurality of bit streams having the same length are produced during successive scan intervals and counting is re-started at the beginning at each scan interval.

3. The method as defined in claim 2 wherein the bit stream information relates to an object edge point location for use in determining a silhouette of the object, said method further comprising:

exposing a linear array of panels to a source of collimated light;

passing said object along a path to form a shadow on a portion of said linear arrays pixels; and

scanning said linear array of pixels to produce an analog information signal which varies in accordance with whether a pixel receives or is shadowed from said light.

4. The method of claim 3 wherein binary transitions occur at time intervals which correspond to scan times of transitions occurring between adjacent pixels which are shadowed and illuminated.

5. A system for determining the position of adjacent points lying along an object edge comprising:

an analog to digital conversion circuit including means to control the amplitude level for digital transition;

means for successively scanning a visual image in one direction of an object to transfer an analog information signal relating to an edge point on said object to said analog to digital conversion circuit to produce a pulse related to a location of said object edge point;

a counter circuit synchronized with said scanning means;

means connecting said analog to digital conversion circuit to a transition detection circuit in order to transfer said pulse to trigger count information from said counter circuit that identifies a location of different ones of said object edge points in successive scans;

a first in, first out buffer memory; and

means for applying to said buffer memory count information limited to that which corresponds to said object edge points based on successive scan information thereby to provide object profile data.

6. The system as defined in claim 5 wherein the buffer memory contains object edge information in the form of a count value for each point in the one direction visual image scan thereby enabling rapid processing of said buffer memory signals as information relating to all of the object edge points is obtained.

7. The system as defined in claim 6 together with a conveyor structure for moving a plurality of singulated like objects relative to a camera sensor and a microprocessor unit connected to the output of said buffer memory, and wherein the buffer memory signals relative to a first object on said conveyor structure are transmitted to the microprocessor before initiating scanning of the next object.

8. The system as defined in claim 7 wherein the system further comprises means for detecting the positions of two aligned points on opposite object edges during each scan, and means operative during each scan to provide count information corresponding to only the positions of each of said two aligned points thereby to provide accurate information concerning the spacing between said two between aligned points on the object without processing analog information signal portions that are unrelated to either of said two aligned points.

9. The system as defined in claim 8 wherein the objects move in a

generally horizontal direction, the camera sensor is stationary, said scan is in a vertical direction and the count information relates to both size and orientation of an object on said conveyor structure.

10. A system for storing information related to an orientation of an object moved by a conveyor in a first direction in a memory circuit connected to receive a plurality of digital signals related to a series of adjacent points on at least one marginal edge of said object comprising:

an analog to digital conversion circuit;

a single linear array of charge coupled devices comprising a plurality of pixels that extend along a second direction that is transverse to the first direction;

a synchronization circuit including means for producing clock signals;

scanning means for producing an analog voltage signal from said pixels operating in synchronization with said clock signals;

means for outputting said analog voltage signal from said pixels to said analog to digital conversion circuit;

an object edge detection circuit coupled to receive output signals from said analog to digital conversion circuit for generating a transfer signal at a time during a scan of the pixels that is related to detection of an object edge point;

a counter circuit operating in synchronization with said clock signals and said scanning means and being reset between successive scans; and

means connecting said memory circuit to receive a count value from said counter circuit which coincides with the time of occurrence of said transfer signals whereby the count value is the only information stored concerning the location of said object edge points.

11. The system as defined in claim 10 wherein said object edge point transfer signal is a pulse that has a duration that is about one-half the duration of output signals from the counter circuit.

12. The system as defined in claim 10 wherein the pixels extend beyond two opposite edges of said object and two transfer signals are generated by said object edge detection circuit to identify the relative positions of points on opposite

marginal edges of said object and provide a size measurement of said object.

13. The system as defined in claim 12 wherein the density of pixels in the linear array is at least about 2000 pixels per inch thereby to provide a size measurements having a resolution at least as small as 0.0025 inches.

14. The system as defined in claim 10 wherein the said transfer signals generated by said object edge detection circuit are connected to open said memory circuit to receive an instantaneous count value from said counter circuit, and said memory circuit has a storage capacity for storing only count values relating to edges of said object and is connected to transfer on a first in, first out basis the stored count value information to a microprocessor.

15. A system for determining a silhouette of an object moving on a conveyor in a first direction comprising:

at least 1000 pixels aligned in a linear array in a direction transverse to the moving direction of the object to extend above and below the object on the conveyor;

scanning means for successively producing an analog signal voltage from each of said pixels which signal is applied to an analog to digital conversion circuit;

means for generating a transfer signal connected to the output of said analog to digital conversion circuit;

a counter circuit operating in synchronization with said scanning means and at a counting speed in excess of 1 MHz;

a memory connected to said counting circuit to receive a count value only in response to receipt of a transfer signal whereby the difference between two count values obtained during a single scan is related to a dimension of that portion of the object imaged by said pixels.

16. The system of claim 15 wherein the memory has a capacity capable of storing in a first in, first out basis all of the count values corresponding to a plurality of points along the horizontal dimension of the object and the system further comprises a microprocessor for processing the stored count values for providing a plurality of object measurements that determine the object silhouette.

17. The system of claim 16 wherein the density of the aligned pixels is about 2000 pixels per inch along the direction of the object dimension being measured thereby to provide measurements having a resolution at least as small as about 0.0025 inches.

18. A method for compacting data substantially as hereinbefore described with reference to the accompanying drawings.

19. An edge determining system substantially as hereinbefore described with reference to the accompanying drawings.

DATED: 26 November 1993

CARTER SMITH & BEADLE
Patent Attorneys for the Applicant:
FMC CORPORATION

ABSTRACT

A high resolution object handling system serves as an object discrimination - identification by creating an object silhouette. The objects are singulated on a conveyor (10) and scanned by a linear array of CCD units (22) (2048 pixels per inch) at a scan rate of 10 MHz. Pixel transitions corresponding to object edge points are converted to a single count value from a counter (10) which is synchronized with the scanner (22). A microprocessor (54) with a first in, first out buffer memory (52) needs only a capacity to handle the count value rather than all data from the pixels (34).

28 8 91 83438

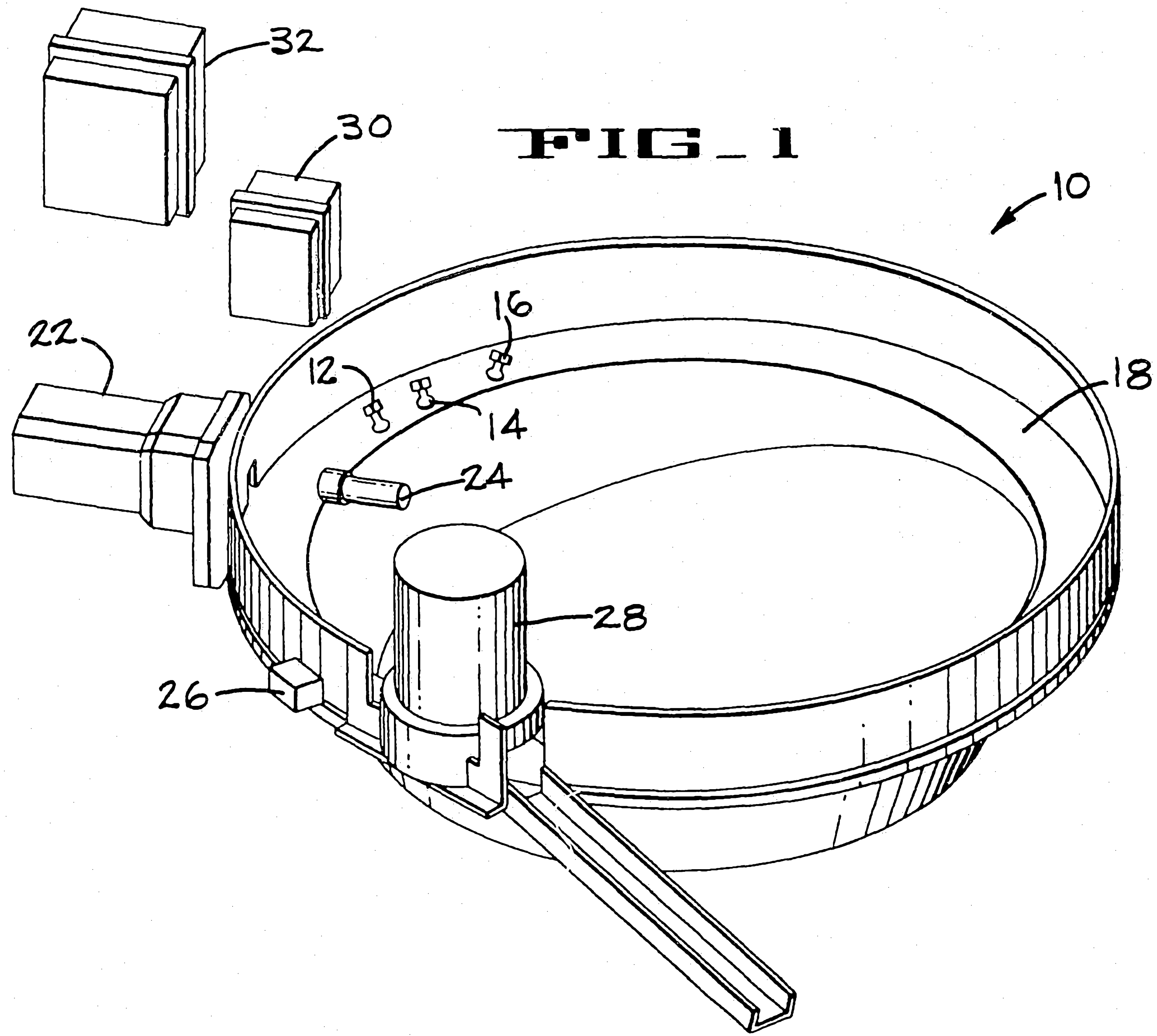


FIG_1

1/5

83438/91

83438/91

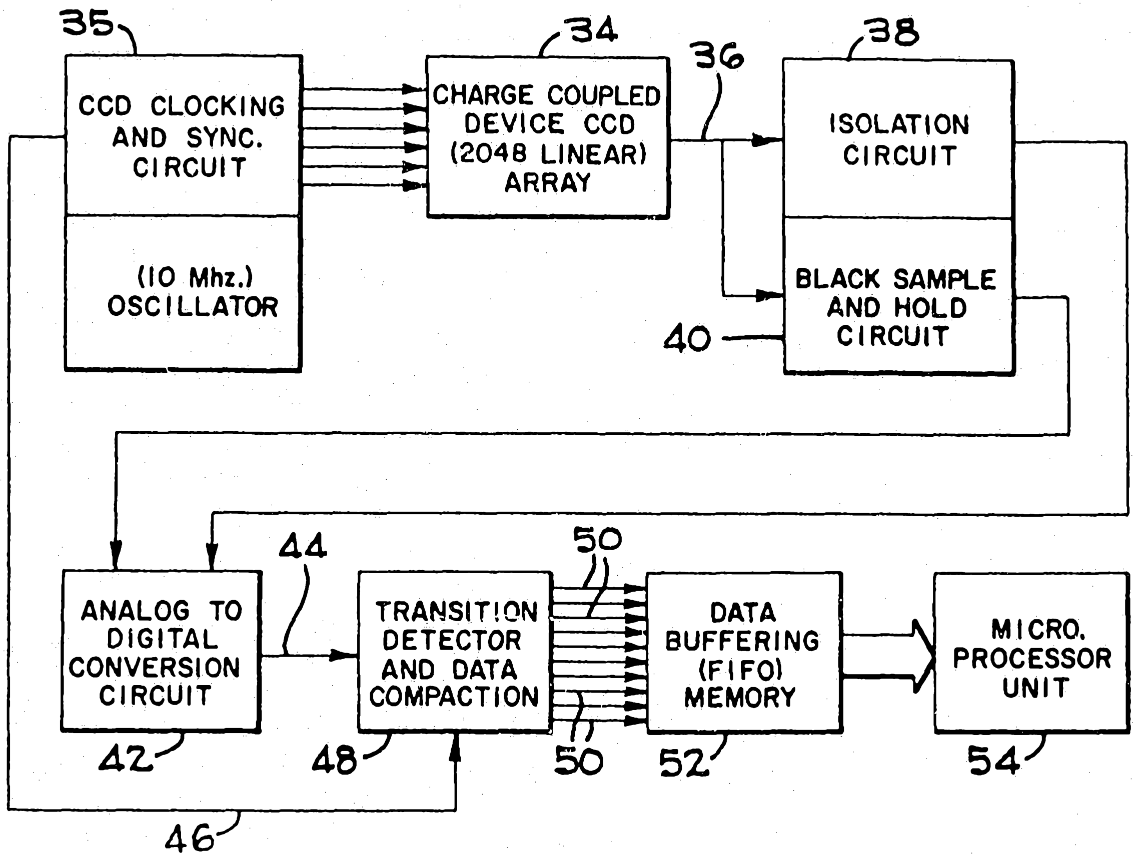


FIG_2

FIG_3

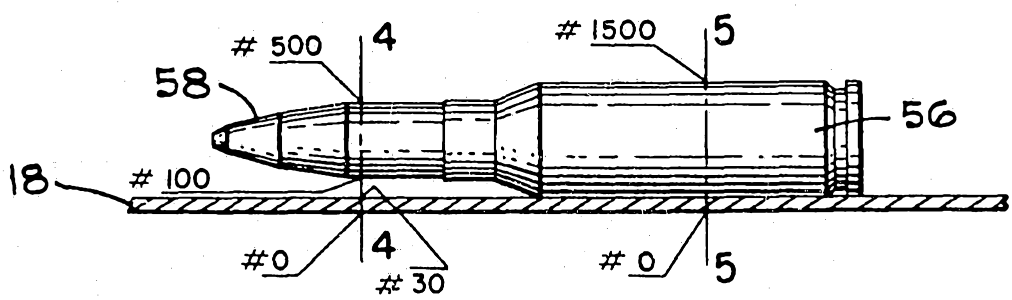


FIG_4

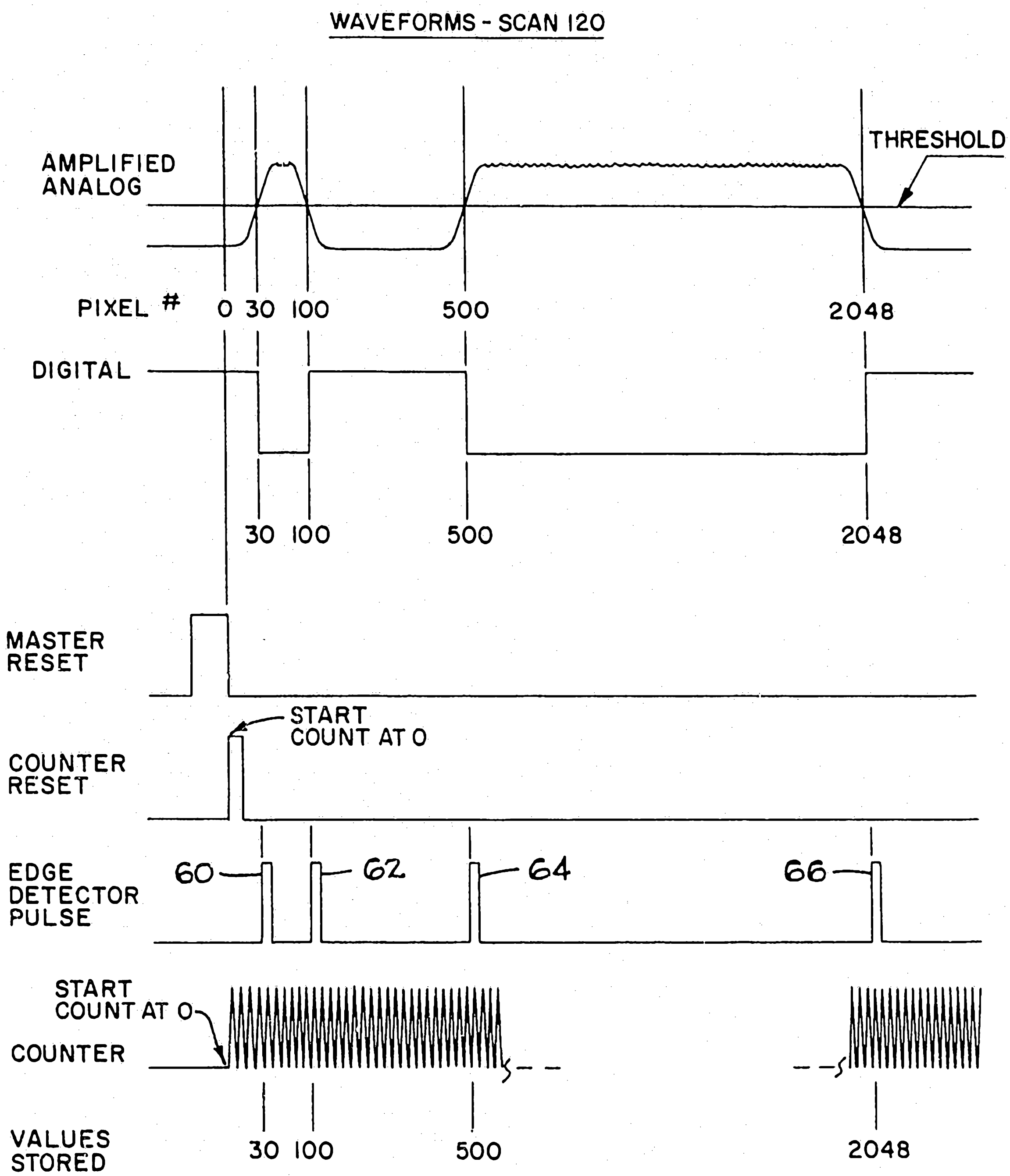

WAVEFORMS - SCAN 120
THRESHOLD
AMPLIFIED ANALOG
PIXEL #
0 30 100
500
2048
DIGITAL
30 100
500
2048
MASTER RESET
START COUNT AT 0
COUNTER RESET
EDGE DETECTOR PULSE
60
62
64
66
START COUNT AT 0
COUNTER
VALUES STORED
30 100
500
2048

FIG_5

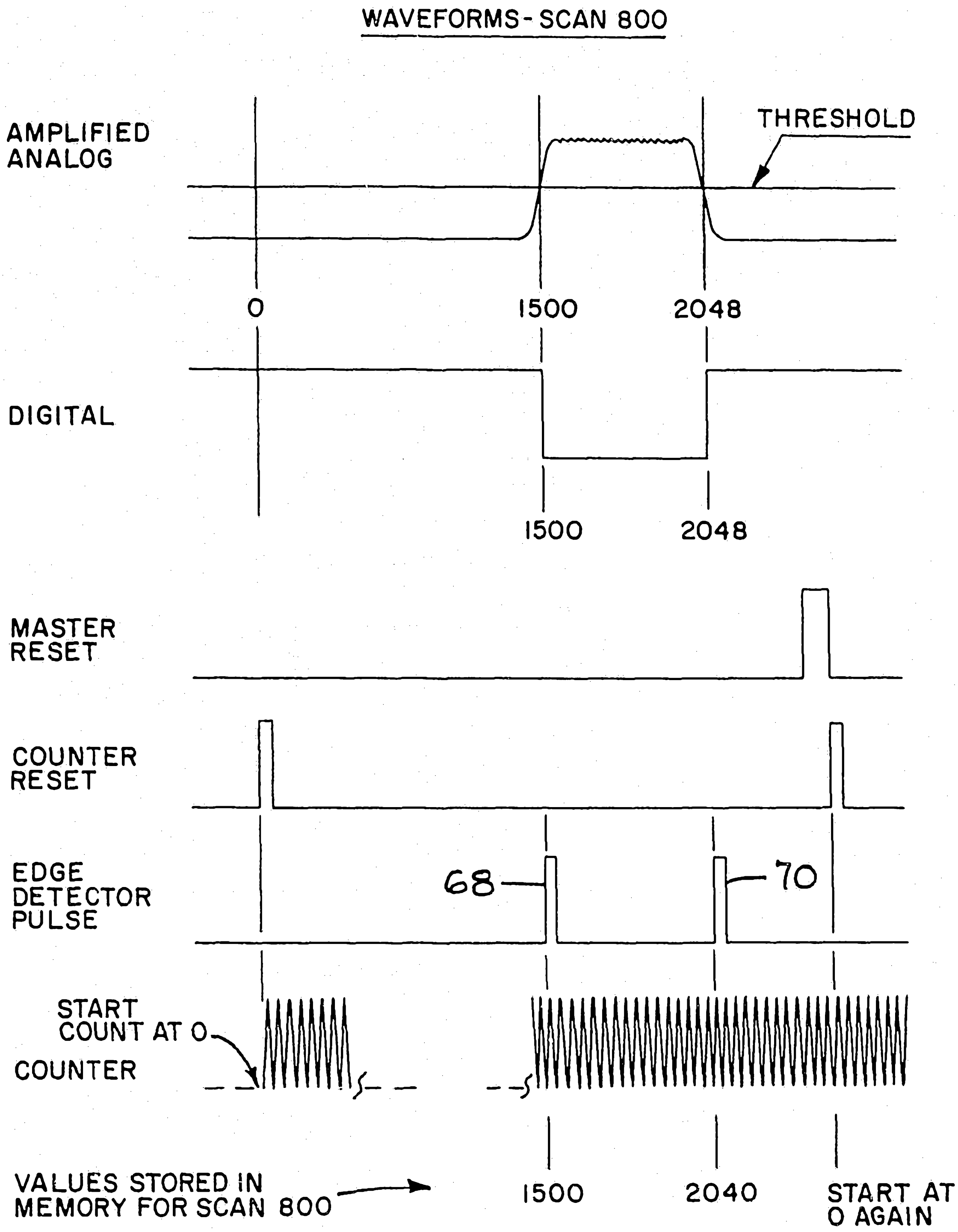
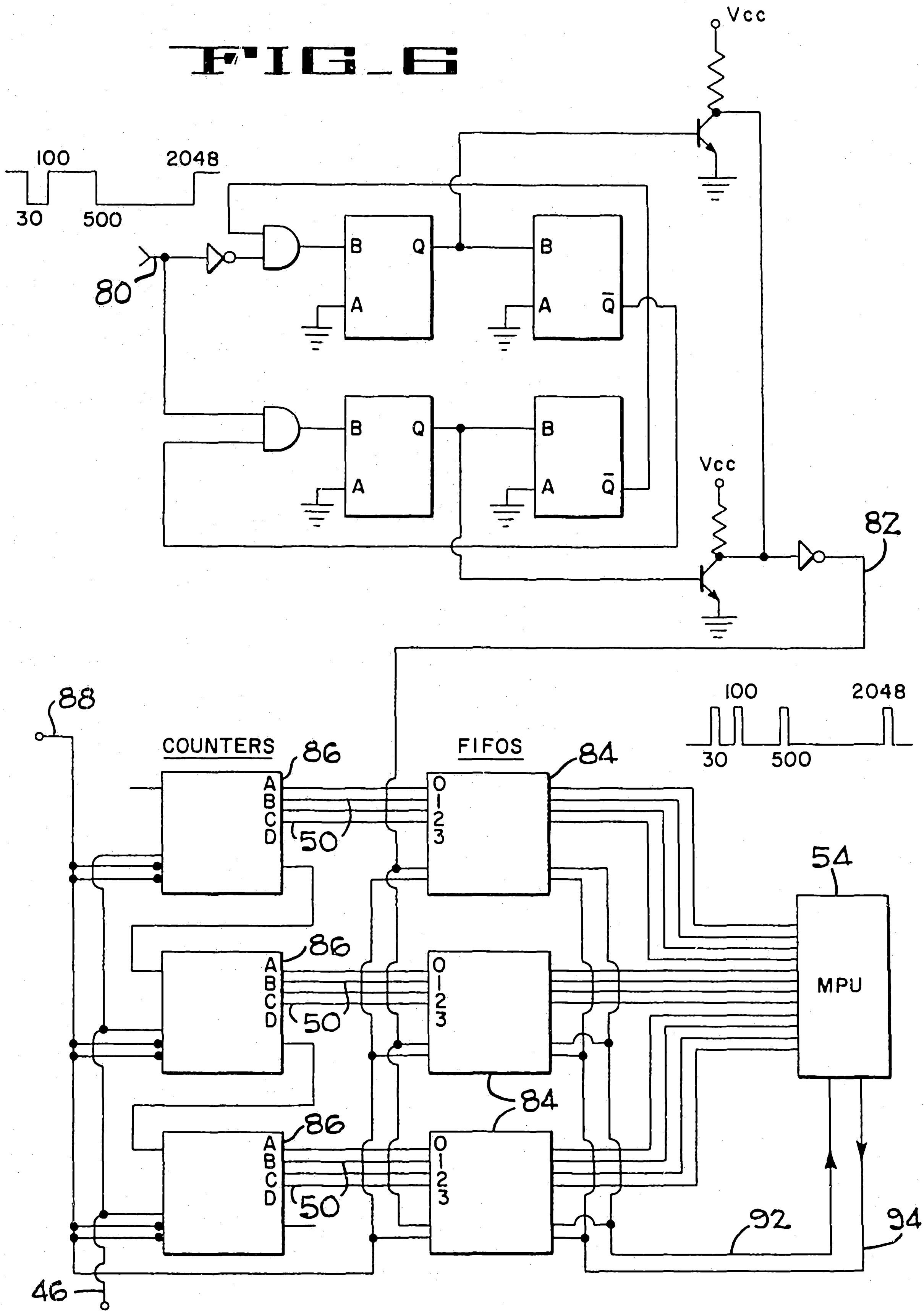

WAVEFORMS-SCAN 800
AMPLIFIED ANALOG
THRESHOLD
0
1500
2048
DIGITAL
1500
2048
MASTER RESET
COUNTER RESET
EDGE DETECTOR PULSE
68
70
START COUNT AT 0
COUNTER
VALUES STORED IN MEMORY FOR SCAN 800
1500
2040
START AT 0 AGAIN

FIG_6



Vcc
100
2048
30
500
B
Q
A
Q̄
80
Vcc
82
88
COUNTERS
86
FIFOS
84
100
2048
30
500
A
B
C
D
0
1
2
3
50
54
MPU
86
84
92
94
46