(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 159 559**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **85103616.0**

(22) Date of filing: **27.03.85**

(51) Int. Cl.⁴: **B 07 C 5/36**

(30) Priority: **27.03.84 US 593739**

(43) Date of publication of application: **30.10.85**
Bulletin 85/44

(84) Designated Contracting States: **DE GB NL**

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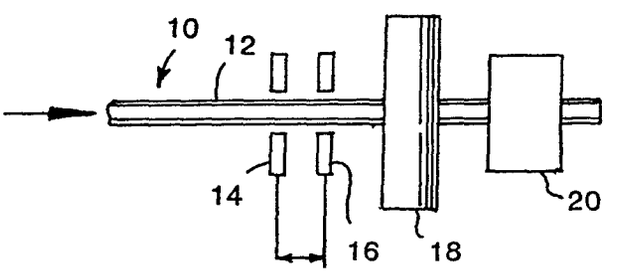
(54) *Method and apparatus for product sorting.*

(57) A new method and apparatus whereby the velocity of an object is utilized to precisely activate a control device. First (14) and second (16) sensors provide an indication of the velocity of the object which is then utilized with predetermined standards representative of system parameters to determine an appropriate time delay before the control device (20) should be activated. A signal functionally representative of the appropriate time is then utilized to provide generally precise timing control of a control device.



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"METHOD AND APPARATUS FOR PRODUCT SORTING"

~~BACKGROUND OF THE INVENTION~~

This invention relates generally to methods and apparatus of sorting, and more specifically relates to methods and apparatus for measuring the velocity of an object and utilizing that velocity in exercising control over the object.

In many environments, such as the food processing industry, it is often desirable to sort bulk quantities of products in response to some objective criteria. When mechanisms are utilized to accomplish this sorting, rather than manpower, this entails the passing of individual products past a sensor adapted to detect indicia of the sorting criteria. The data from the sensors is then utilized to exercise control over the product, such as to activate an ejector to reject the product.

As a particular example, in the manufacture of french fries, existing techniques of sorting include transporting the french fries generally single file through a conduit, typically through use of a current of water. The french fries pass by a sensor adapted to detect a defect in a french fry. If a defect is detected, the sensor activates an ejector mechanism, which, after a fixed delay time to allow the french fries to travel downstream to a location proximate the ejector mechanism, will remove the french fry from the main product stream. Although satisfactory for many applications, this type of system includes several possibilities for error. For example, such a system presumes that the carrier water moves at a constant velocity and the that transported products, the french fries, are moving at the same, constant velocity. This is not always the situation. Differences in density and size may cause the products to move through the system at different velocities. Because a fixed delay time between the detection of the defect and the ejector mechanism is

utilized, this change in velocity establishes an opportunity for an erroneous ejection of the product. Although the signficance of the different product velocities may be minimized by placing the ejector very close to the sensors, such placement is also not always possible.

Additionally, to avoid waste and needless rejection of products such as french fries, it is often desirable to attempt to cut away and remove the defective portion, leaving the satisfactory portion of the product in the main product stream. To accomplish this type of operation requires extreme timing accuracy and coordination between the defect sensor and the cutting mechanism. Furthermore, because it is often not practical to physically situate the cutting mechanism immediately adjacent to the defect sensors, any error introduced into the system by a product velocity other than the assumed norm may potentially have a significant detrimental effect upon the processing operation.

Accordingly, the present invention provides a new method and apparatus for determining the velocity of a product in a sorting operation and for utilizing that determined velocity to exercise a desired control over the product.

~~SUMMARY OF THE INVENTION~~

In a preferred embodiment, a method and apparatus in accordance with the present invention includes first and second sensors which are spaced a fixed, known distance apart along the path of an object which is to be sorted. The two sensors cooperatively establish an electronic signal representative of the time period between the arrival of the object proximate the first sensor and the arrival of the object proximate the second sensor. This signal is therefore functionally representative of the

velocity of the object. This electronic signal is utilized to enable a counter, which then determines a discrete number of pulses representative of the objects' velocity. A programmable read only memory (PROM) translates these counts utilizing data representative of the distance the object must pass before an appropriate control means should be activated, the travel time of an object moving at its measured velocity, and the activation time of the control system, to appropriately preset a counter. The counter cooperates with a shift register to provide a signal to activate the control system at the appropriate time.

In the accompanying drawings:

~~BRIEF DESCRIPTION OF THE DRAWINGS~~

FIG. 1 illustrates schematically a sorting apparatus in accordance with the present invention.

FIG. 2 illustrates electronic circuitry in accordance with the present invention, depicted in block diagram form.

FIG. 3 illustrates the electronic circuitry of FIG. 2 in more detailed schematic form.

FIG. 4 illustrates a product sensor of FIG. 1, depicted in block diagram form.

FIG. 5 illustrates an alternative embodiment of a portion of a sorting method and apparatus in accordance with the present invention.

~~DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT~~

Referring now to the drawings in more detail, and particularly to FIG. 1, therein is illustrated a portion of a sorting assembly 10 including apparatus in accordance with the present invention. For purposes of this description, sorting assembly 10 will be described as one of a

type as might be utilized to sort french fries. However, it should be readily understood that this invention is not limited to such application, and further is not limited in application to the sorting of food products.

Sorting assembly 10 includes conduit 12 through which the french fries and a carrier fluid, preferably water, are transported. First and second product sensors, 14 and 16, respectively, are situated proximate conduit 12. These sensors may be of any suitable type, but are preferably of a photoelectric type and most preferably are infrared photoelectric sensors.

Referring now to Figure 4 of the drawings, therein is illustrated in block diagram form an embodiment of product sensor suitable for use with the present invention. The concern presented in attempting to determine the times at which a product will pass first product sensor 14 and second product sensor 16 is to determine the arrival of the product at each sensor at the appropriate time regardless of where that product is located within conduit 12. It has been found that this concern may be overcome by use of a fiberoptic emitter adapted to present a long, thin image along an axis generally perpendicular to that of conduit 12, and use of a suitable receiver for such emitter. For example, a emitter optical fiber 80 such as that manufactured by Banner Engineering Corporation of Minneapolis, Minnesota and designated as IR2.53S has been found satisfactory for these purposes. Emitter optical fiber 80 is preferably coupled to an LED scanner 84 such as is also manufactured by Banner Engineering Corp. and designated as SM53E. The receiver optical fiber 82 is preferably coupled to a DC scanner such as that manufactured by Banner Engineering Corp. and designated SM53R. The output of this DC scanner is amplified by a high gain pulse amplifier, also such as one manufactured by Banner

Engineering Corp. and designated B4-6. This type of sensor is suitable for use as both first product sensor 14 and second product sensor 16.

Where first and second product sensors 14, 16 are of a photoelectric or similar type, conduit 12 will preferably be constructed of a transparent material such as plexiglass to allow operation of the sensors from a location exterior to conduit 12. First and second product sensors 14, 16 are spaced a fixed distance apart. In one embodiment in which the french fries are intended to move at an average speed of approximately 10 meters per second (32.8 feet per second), first and second product sensors 14 will preferably be longitudinally spaced two inches apart along conduit 12.

Downstream of first and second product sensors 14, 16 and proximate conduit 12 is defect detection viewer 18. Defect detection viewer 18 may be of any one of various types known in the industry for detecting a defect, but preferably is a photoelectric type, and most preferably is of a photoelectric type where the color or darkness of a product is compared to an established standard to determine if a defect in the product is present.

Downstream of defect detection viewer 18 is defect removal mechanism 20. Defect removal mechanism 20 may again be of one of several types known to the industry. For example, one type of defect removal apparatus used in the industry is one which directs a burst of compressed air at a product from one side, thereby causing the path of that product to divert toward the other side of the conduit and to exit from the main product stream through a reject passage or conduit. However, the present invention is believed to have particular significance and advantage when a mechanism such as a cutting mechanism is utilized to remove a defect from a portion of the product, leaving the remainder of the product intact.

One such cutting mechanism is a rotating wheel having a plurality of selectively extendable and retractable blades around its circumference. The wheel is cooperatively situated with conduit 12 and the associated product stream to allow unobstructed passage of a product past the blades when the blades are in the retracted position and to intersect and cut the product when the blades are in the extended position. The extension and retraction of the blades is controlled by an electronic logic signal. The signal establishes the number of blades which are extended at a given time. Thus, an appropriate number of blades may be extended at an appropriate time so as to cut away a portion of a french fry containing a defect, leaving the non-defective portion intact.

Referring now to FIG. 2, therein is illustrated electronic circuitry suitable for use with the present invention, depicted in block diagram form. Signals from first product sensor 14 indicating the presence of a product proximate such sensor are input to first synchronous one-shot 22. Similarly, signals from second product sensor 16 indicating the presence of the product proximate that sensor are input to second synchronous one-shot 24. An output pulse from first synchronous one-shot 22 is input to a count enable circuit 25. Count enable circuit 25 communicates an "enable" signal to counter B 30 to start counting clock pulses input from counter A 27 and pulse stretcher 29.

The pulse output of second synchronous one-shot 24 is input to count enable circuit 25, valid count determining circuit 26, and delayed reset circuit 28. The pulse output stops the "enable" signal to counter B.

Valid count determining circuit 26 cooperates with counter B 30 and decoder 32 to determine if the time between output pulses of first and second synchronous one-shots 22 and 24 is within a predetermined limit which

would indicate a valid velocity measurement. If the count appears to be valid, a latch enable circuit 34 enables latch 36 to store the count data from counter B 30. This count data is functionally representative of the velocity of the product. A portion of the address to PROM 38 is formed by the count stored in latch 36 and the remaining portion is formed by an indicator of the distance which the product must travel to reach defect removal device 20. In response to this composite address, PROM 38 outputs a signal functionally representative of the actual delay necessary to cut the french fry at the desired time.

In some applications, this actual delay time may be a linear function dependent upon the velocity of the product and the distance to the defect removal mechanism. However, dependent upon the type of defect removal mechanism 20 which is utilized, this actual delay time necessary for desired operation of the mechanism may not be such a linear function. When a defect removal mechanism 20 such as the wheel cutter described earlier herein is utilized, the necessary delay time includes two components: a linear component which is representative of the generally constant time for appropriate blades on the wheel to be extended; and a non-linear component which is a function of the velocity of the product, as represented by the counts in latch 36. In the preferred embodiment described herein, PROM 38 utilizes these linear and non-linear components, and also the fixed pipe length, i.e., the distance from the defect detector 18 output to defect removal mechanism 20, and does a mapping to generate a signal functionally representative of the necessary actual delay time before defect removal mechanism 20 should be activated. In a preferred embodiment, PROM 38 outputs a signal to counter D 40 which presets counter D 40 to

divide a set clock frequency to a frequency which will clock shift register 42 to output a defect signal which activates defect removal mechanism 20 at the correct time.

Referring now to FIG. 3 of the drawings, therein is shown the circuitry of FIG. 2, depicted in more detailed schematic form. Timing of the illustrated embodiment is provided by oscillator 50 which preferably includes an appropriate two MHz crystal to establish a primary 2 MHz clock frequency (CLK). This 2 MHz clock frequency is utilized as the primary time reference for the system.

Counter A 27 divides the 2 MHz clock frequency by 2 and 4 to provide, respectively, a 1 MHz clock frequency (CLK/2) and a 500 KHz clock frequency (CLK/4) for use in selected timing functions within the circuit. Counter A 27 also divides the 2 MHz clock frequency to a 17.699 KHz frequency utilized as the timing reference measuring the velocity of a product past the first and second product sensors (14 and 16, respectively, in FIG. 1).

Counter A 27 is preferably composed of two synchronous up/down counters 54, 56 such as those manufactured by Texas Instruments, Inc. and designated as 74LS193.

As indicated earlier herein, counter B 30 functionally determines the actual velocity of the product past first and second sensors (14 and 16, respectively, in FIG. 1). Counter B 30 preferably includes two synchonous four bit counters 57, 58, such as those manufactured by Texas Instruments, Inc. and designated as SN74LS161.

In making the velocity determination, signals from first product sensor 14 are input to first synchronous one-shot 22. First synchronous one-shot 22 includes a portion of a quad D-type flip-flop 61, such as that manufactured by Texas Instruments, Inc. and designated 74LS175, and a two input positive-NAND gate 63. When the first product sensor detects a product, a positive signal (SIG O) will be input to first synchronous one-shot 22.

In response to this signal, first synchronous one-shot 22 will establish a negative pulse which is a maximum of two microseconds long. This negative pulse is input to count enable circuit 25. A maximum pulse time of two microseconds is preferably established for this output pulse. This maximum pulse width is established to prevent counting error from occurring due to the presence of a product which encounters both first product sensor 14 and second product sensor 16 concurrently.

Similarly, as the product passes second product sensor 16, a positive signal will be input to second synchronous one-shot 24 which is of comparable construction to that of first synchronous one-shot 22. Second synchronous one-shot will therefore establish a negative pulse in response to the signal from second product sensor 16.

The output of flip-flop 60 is utilized to enable Counter B 30. Count enable circuit 25 preferably includes a portion of a D-type flip-flop 60, such as that manufactured by Texas Instruments, Inc. and designated as 74LS74. The output of first synchronous D flip-flop 60 is utilized as an S-R flip-flop. The output of second synchronous one-shot 24 is applied to the "R" input of flip-flop 60.

A valid count determining circuit 26 determines if the signal from count enable circuit 25 is representative of a velocity within a predetermined, valid range. Valid count determining circuit preferably includes a D flip-flop 64 such as that utilized in count enable circuit 25. After being enabled by flip-flop 60, counter B 30 begins counting. Once counter B 30 reaches a predetermined minimum count, which is representative of a low valid product velocity value, decoder 32 decodes such count and sets D-type flip-flop 64 of valid count determiner 26. In the illustrated embodiment this minimum count is 80, repre-

senting a minimum velocity of approximately 23 feet per second (7 metres per second). If counter B 30 reaches a second, maximum, predetermined count, representative of a maximum velocity value, such count will be input to valid count determiner circuit 26 and flip-flop 64 and counter B 30 will be reset automatically. In the illustrated embodiment, this maximum count is 128, representative of a maximum velocity of 36 feet per second (11 metres per second).

The output of second synchronous one-shot 24 is also applied to delayed reset circuit 28. Delayed reset circuit 28 preferably includes another quad D-type flip-flop 63 such as that utilized in synchronous one-shots 22 and 24. Delayed reset circuit 28 delays the output (reset) pulse from second synchronous one-shot 24 while the valid count determination is made. The reset pulse is delayed to assure that, when a valid count is determined, that count is loaded into latch 36 before counter B 32 is reset. If the count is valid, counter B 30 will be reset by a signal from delayed reset circuit 28. Delayed reset circuit 28 is automatically cleared through a use of a positive NAND gate 65.

Once a valid count is determined, an enable signal is communicated to latch enable circuit 34. Along with the output of second synchronous one-shot 24, this enable signal enables latch 66, which loads the counter value from counter B 30. Latch 36 then addresses PROM 38. PROM 38 is preferably of a type manufactured by Texas Instruments, Inc. and designated as 2516 JL.

In operation of the system, the pipe length, described earlier herein, is input to the PROM 38 by means of a plurality of switches 68. These switches provide a portion of the PROM address, this portion being indicative of the fixed parameter of the system operation, the distance the product will travel after detection and before cutting.

For each programmable pipe length, PROM 38 has stored a complete set of preset values for counter D functionally related to the available measured counts from counter B. These preset values may be determined either empirically, statistically, or mathematically through conventional techniques for the particular system being utilized. When loaded, latch 36 also addresses PROM 38, and particularly addresses a particular stored preset value for counter D. PROM 38, therefore, in essence does a mapping based upon the pipe length set by switches 68, the fixed delay in the system (the time required to enable the appropriate blades on the cutting wheel) and the velocity of the product (represented by the counts from counter B) to determine the preset value for counter D 40.

PROM 38 appropriately presets counter D 40 which then divides the 2 MHz a frequency to clock 256 bit shift register 42 to establish the appropriate timing for a defect signal to activate defect removal mechanism 20, i.e., in the exemplary embodiment, to extend blades on the described cutting wheel. Counter D 40 is preferably of similar construction to counter A 27. Shift register 42 is preferably one such as that manufactured by Motorola, Inc. and designated as MC14517. A pulse stretcher circuit 41 is utilized to insure that the pulses of divided shift register frequency are sufficiently wide to serve as clock pulses for shift register 42.

Product defect viewer 18 provides a durational error signal to shift register 42 which will determine the duration of the signal in response to the defect. An actual defect signal will not be generated unless product defect viewer 18 inputs a data signal to shift register 42 representative of a defect in the viewed product.

Referring now to Figure 5 of the drawings, therein is depicted in block diagram form a portion of an alternative embodiment of a sorting apparatus in accordance with the

present invention. This alternative embodiment allows the tracking of an individual product through the system such that defect removal mechanism 20 is activated in response to the measured velocity of that individual product.

In this embodiment, instead of counter D and an associated shift register (elements 40 and 42, respectively, in Figures 2 and 3), a plurality of parallel counter circuits 70 are utilized. Although in Figure 5, four counter circuits 70 are illustrated, it is to be readily understood that any number as is practical may be utilized. The number of necessary counter circuits 70 will depend upon the general time period required for objects to pass from the product sensors (elements 14 and 16 in Figure 1) to defect removal mechanism (20 in Figure 1).

Each counter circuit includes a latch 72A, 72B, 72C, 72D to which the signal output of PROM 38 is applied. As depicted in the drawing, the output of PROM 38 is applied in parallel to each latch 72A, 72B, 72C, 72D. Each latch is cooperatively coupled to a respective counter 74A, 74B, 74C, 74D, and a respective shift register 76A, 76B, 76C, 76D. The output of each shift register is then preferably coupled through a gate 79 to defect removal mechanism 20. Sequencer 78 is utilized to selectively enable each latch to retain the data from PROM 38. Sequencer 78 will be enabled by the enabling pulse from count enable circuit 25. Sequencer 78 is also cooperatively coupled to a plurality of gates 77A, 77B, 77C, 77D. The output of product defect viewer 18 is also coupled in parallel to gates 77A, 77B, 77C, 77D. This assures that the defect signal from product defect viewer is appropriately timed with the input to each shift register 76A, 76B, 76C, 76D.

In operation of the embodiment, as sequencer 78 is enabled by count enable circuit 25, it enables a first latch 72A to retain output data from PROM 38. This data

presets counter D (1) 74A which then functions with shift register 76A in a manner identically to that described previously with respect to counter D 40 and shift register 42 to supply a "data out" signal to defect removal mechanism 20. (if a defect signal has been supplied from defect detection viewer 18). As the next enable signal is received from count enable circuit 25, sequencer 78 enables latch 72B to store the mapping data from PROM 38 and a similar operation is carried out by counter D (2) 74B and associated shift register 76B. This process is then cycled through the remaining circuits 70, at which time the cycle will begin again.

Many modifications and variations may be made in the techniques and structures described herein and depicted in the accompanying drawings without departing from the scope of the present invention. Accordingly, it should be readily understood that the embodiments described and illustrated herein are illustrative only and are not intended as limitations upon the scope of the present invention.

The features disclosed in the foregoing description, in the following claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

CLAIMS
~~We claim~~:

1. A sorting apparatus for sorting objects moving along a generally predetermined path, comprising:

first means for detecting the arrival of an object at a first location along said path;

second means for detecting the arrival of said object at a second location along said path;

means for determining the period between the arrival of said object at said first location and the arrival of said object at said second location;

means for selectively exercising control over said object; and

means responsive to said determined period for causing said control means to exercise control over said object as said object reaches a desired location along said path.

2. The sorting apparatus of Claim 1, wherein said first detecting means comprises a photoelectric sensor.

3. The sorting apparatus of Claim 1 or 2, wherein said second detecting means comprises a photoelectric sensor.

4. The sorting apparatus of Claim 1, 2 or 3, wherein said determining means comprises a counter cooperatively associated with said first and second detecting means to count units of time between the arrival of said object at said first detecting means and the arrival of said object at said second detecting means.

5. The sorting apparatus of any one of Claims 1 to 4, wherein said means responsive to said determined period for causing said control means to exercise control over said object comprises means for utilizing an established activation time for said control means, said determined period and to the distance between said sensors and said control means to address a set of pre-established values to selectively activate said control means.

6. An apparatus for sorting objects moving along a generally predetermined path, comprising:

a first photoelectric sensor for detecting the arrival of an object at a first location along said path and for generating a signal representative of such arrival;

a second photoelectric sensor for detecting the arrival of said object at a second location along said path and for generating a signal representative of such arrival;

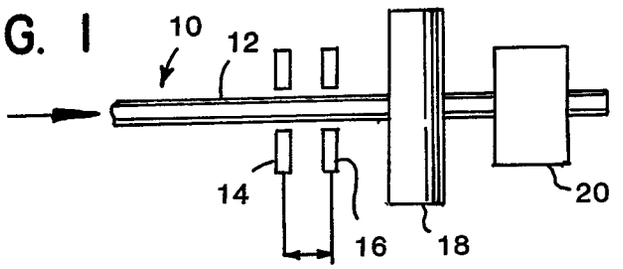
counter means for counting the time period between said signal from said first sensor and said signal from said second sensor;

means for detecting a characteristic of said object, for which characteristic at least a portion of said object is desired to be removed from said generally predetermined path;

control means for selectively removing at least a portion of said object;

means responsive to said time period for selectively activating said control means to remove at least said desired portion of said object from said predetermined path.

FIG. 1


10
12
14
16
18
20

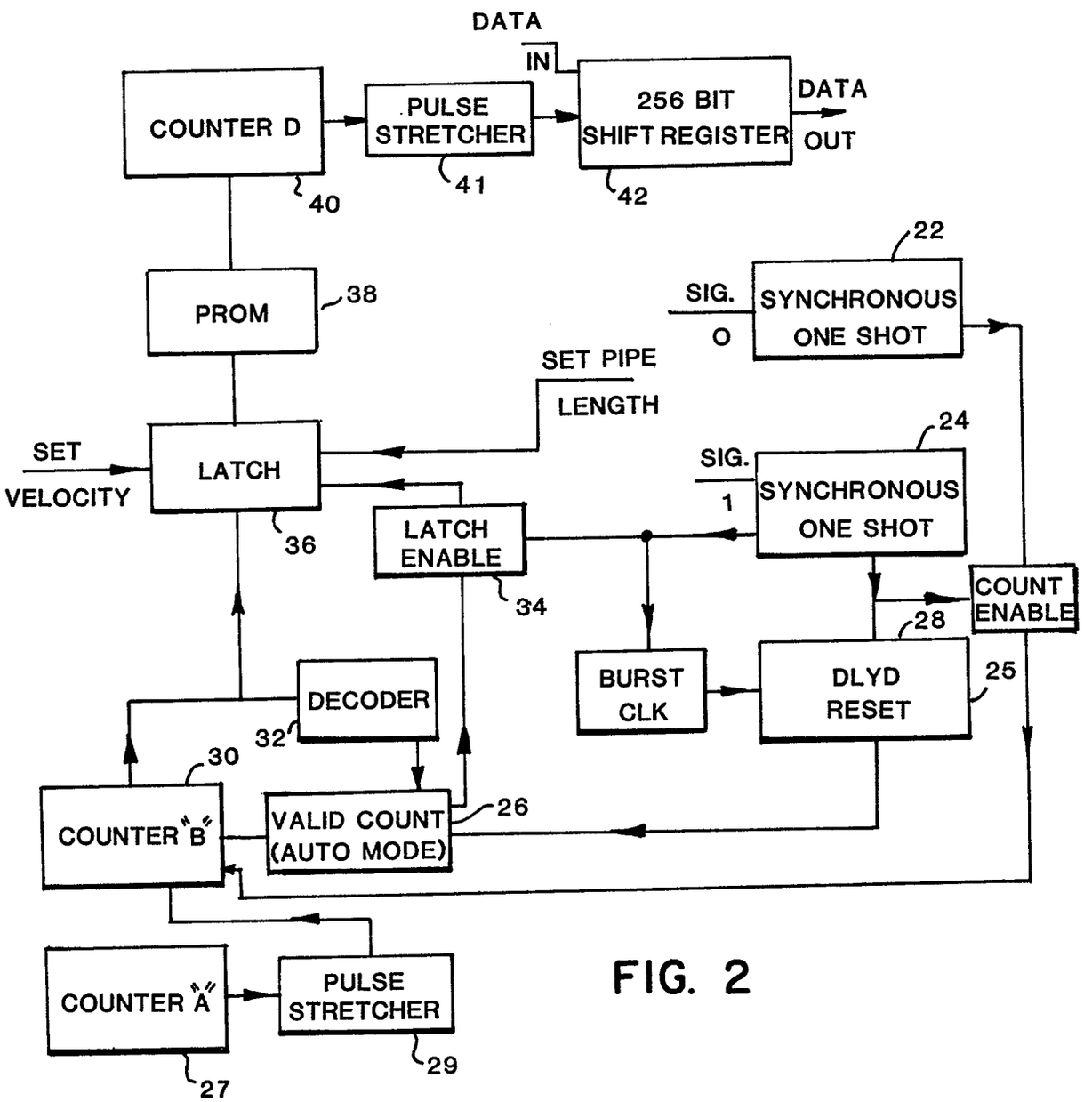

DATA
IN
COUNTER D
PULSE STRETCHER
256 BIT SHIFT REGISTER
DATA OUT
40
41
42
22
PROM
38
SIG. O
SYNCHRONOUS ONE SHOT
SET PIPE LENGTH
SET VELOCITY
LATCH
36
24
SIG. 1
SYNCHRONOUS ONE SHOT
LATCH ENABLE
34
COUNT ENABLE
28
BURST CLK
DLYD RESET
25
DECODER
32
30
COUNTER "B"
VALID COUNT (AUTO MODE)
26
COUNTER "A"
PULSE STRETCHER
27
29

FIG. 2

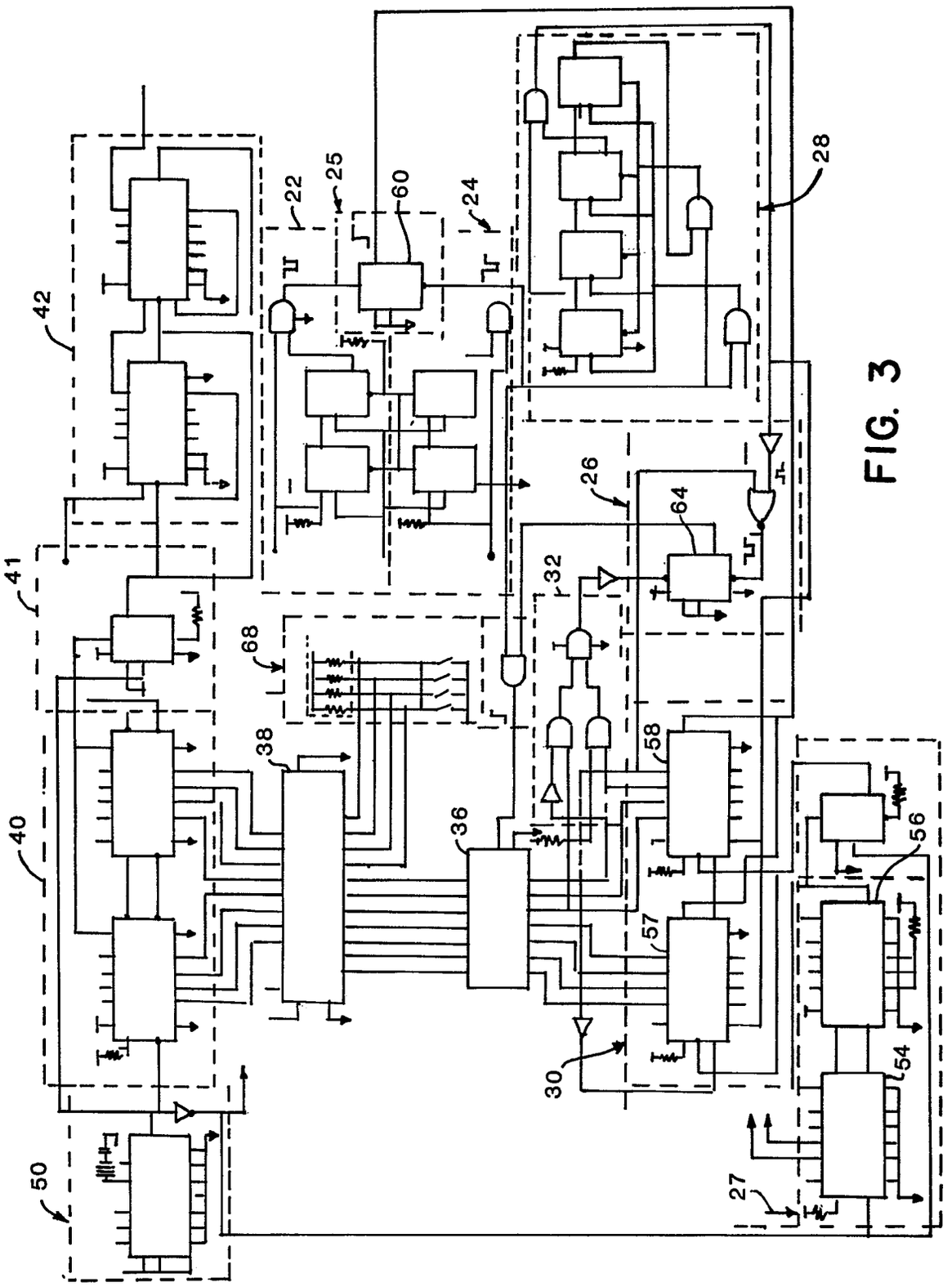


FIG. 3

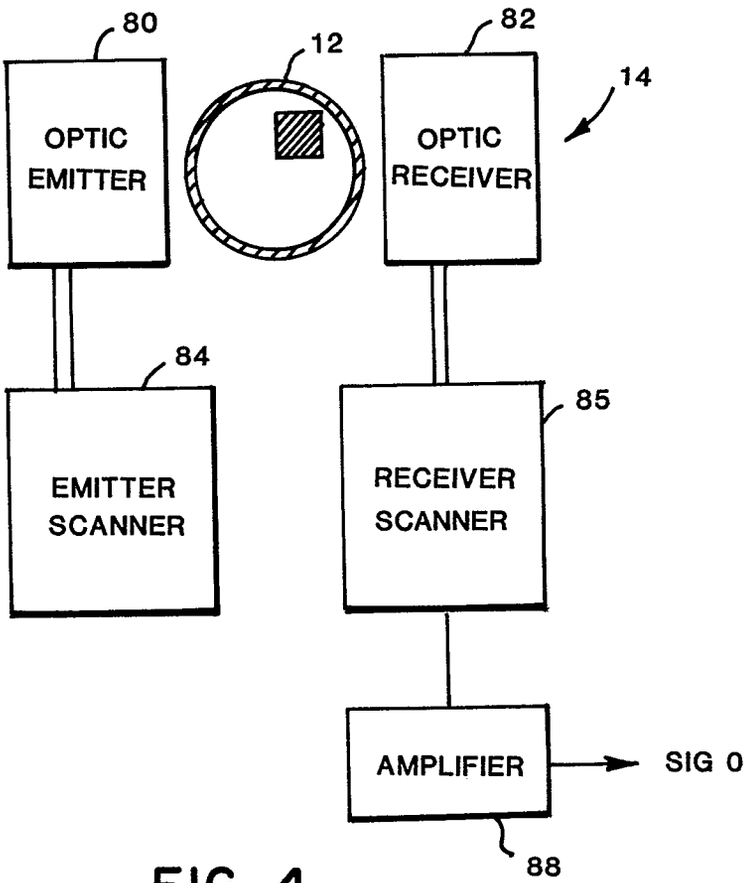

80
12
82
14
OPTIC EMITTER
OPTIC RECEIVER
84
85
EMITTER SCANNER
RECEIVER SCANNER
AMPLIFIER
SIG 0
88

FIG. 4

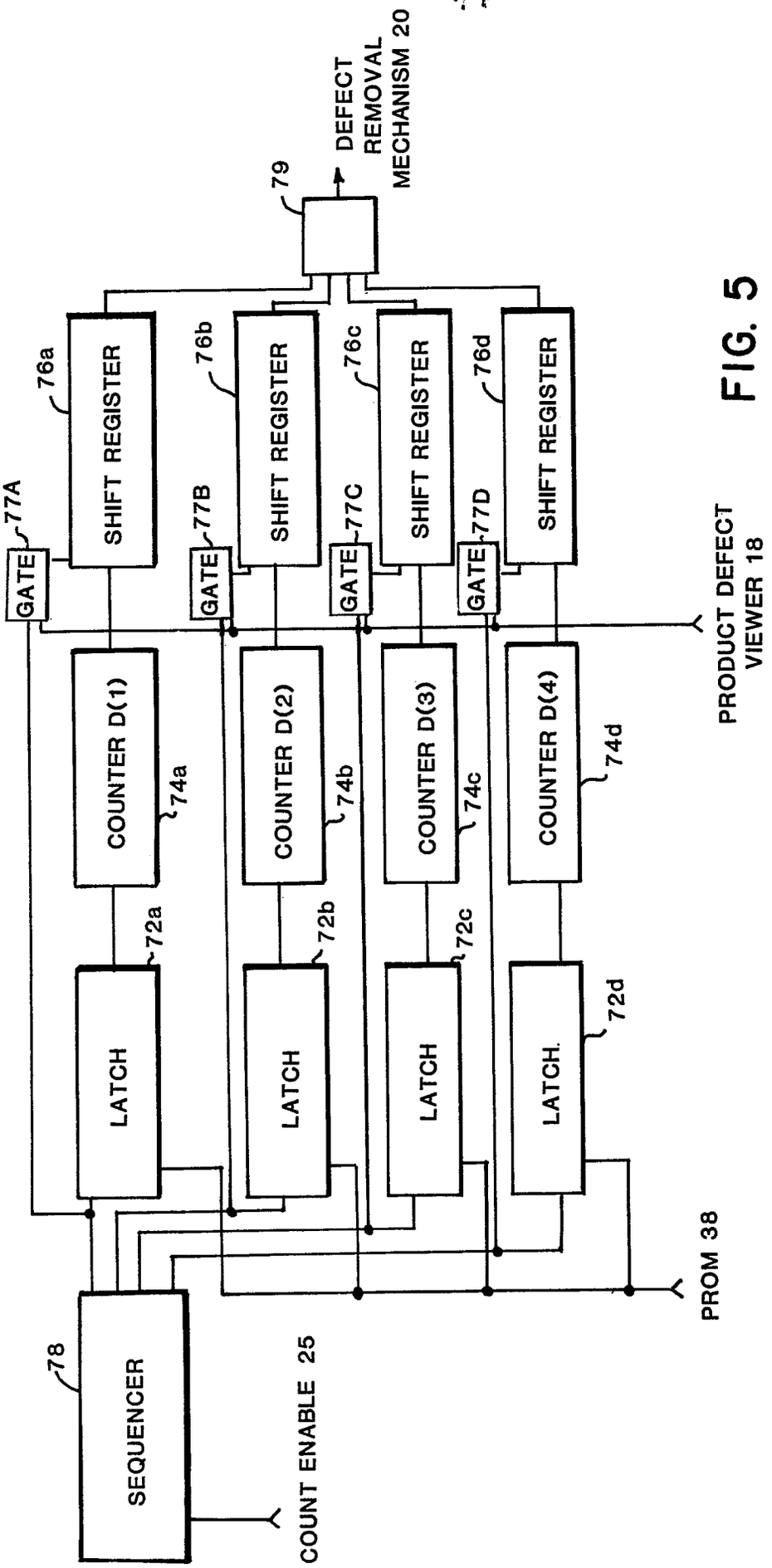

DEFECT REMOVAL MECHANISM 20
79
SHIFT REGISTER
76a
76b
76c
76d
GATE
77A
77B
77C
77D
PRODUCT DEFECT VIEWER 18
COUNTER D(1)
COUNTER D(2)
COUNTER D(3)
COUNTER D(4)
74a
74b
74c
74d
LATCH
72a
72b
72c
72d
PROM 38
SEQUENCER
78
COUNT ENABLE 25

FIG. 5