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(54) Separation system for continuous wrapping material.

(57) A wrapper feed control system includes a feed mechanism 3,7 for feeding continuous wrapping material 1 to a separating station employing knives 4. A detector 5 scans the material to detect registration marks 2 and this information passes to computation unit 10 which also receives information from synchronising switch 9 and pulse generator 11 and from these determines any error in the registration mark position relative to the machine cycle. A variable correction is made via motor 6 to increment or decrement the feed dependent on the computed error.

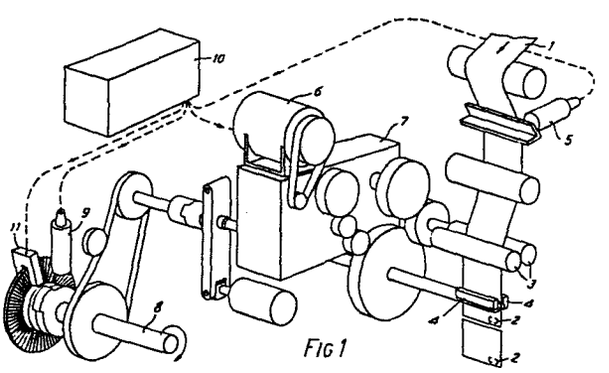

FIG 1

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The invention relates to a wrapper feed control system having a feed mechanism for feeding to a separation station continuous wrapping material of the type carrying a registration mark for detection purposes.

When packaging products in flexible materials (e.g. paper, aluminium foil, plastic film) which are supplied in reeled lengths it is ofen desirable to cut the individual wraps from the continuous length at some fixed point in relation to a graphic design printed on the wrapping material.

Problems arise due to an error occurring at the fixed cut off point so that individual wrappers carry incomplete graphic designs made up of portions meant for an earlier or later wrapper. To avoid this, a continuous design is often chosen so that there is no need to run the material in synchronism with the machine cycle. However, this choice is likely to detract from the display properties of the finished package.

In order to accommodate wrappers each carrying a separate design it is necessary to use some kind of registration system. Known systems require a mark to be included in the printed design of the individual wrapper of a colour and intensity which contrast sharply with a uniform background. Usually there is a minimum distance for which this uniform background should extend in front of and behind the printed mark (relative to the direction of motion of the material in the packaging machine). The mark is

required to appear on every individual wrapper with the distance between marks along the length of the wrapping material having to be controlled quite accurately to conform to the intended wrapper length. (Typically the pitch is required to be within $\pm\frac{1}{2}\%$ or better.) To correct registration errors these systems comprise one of two types, viz those which correct errors by feeding more than the length of material normally drawn by the machine in any one cycle and those which underfeed material to correct the wrapper position. The principles however, are the same in each case and occasionally both options are available though mutually exclusive.

The first principle of system design is that there should be a small difference between the printed length of the individual wrap and the length of material which is drawn into the machine during one machine cycle when no corrective action is applied. For example, a machine which is built to correct wrapper position by overfeeding will take slightly less material than the printed length (typicaly 99%) during a normal machine cycle; this causes the printed mark to arrive slightly later in each successive cycle.

Secondly, the packaging machine is provided with a photo-electric detection device focussed on a spot in the path which the printed registration marks follow through the machine.

Thirdly, the packaging machine is fitted with a switching arrangement which causes an electrical signal to be generated at the time (or period of time) in each cycle when the printed registration mark should appear at the point of focus of the photoelectric detector.

Fourthly, the packinging machine is fitted with an electro-mechanical device to cause a fixed alteration to the length of wrapper drawn through the machine in any one chosen cycle. (Typically a correction of ½% to 3% depending on the purpose for which the machine was designed, but a fixed amount for any one machine).

Considering now the combination of these four physical features and taking again as the example a machine which corrects by overfeeding we have the following result:-

1. The machine operator sets up the machine so that the registration mark falls under the photoelectric detector at the moment in the machine cycle when the timing signal is generated.
2. The machine is started and immediately successive registration marks appear successively later in the machine cycle until the moment when no mark is present at the appropriate time.
3. The corrective mechanism is operated to feed a fixed amount of additional material such that the next

registration mark will fall under the eye at the appropriate time.

4. The process is repeated.

A fifth feature which is often provided is a second switching arrangement to desensitise the photoelectric detector during a major part of the machine cycle so that beyond the minimum printed background any form of printed design may appear without causing unwanted corrective action.

These principles apply regardless of whether the feed of wrapping material through the machine is continuous or intermittent.

There are a number of ways in which the systems described can fail.

1. Inaccuracies in the printing cause variations in the printed length such that either (a) registration marks drift in the wrong direction and are never recovered or (b) the drift in the intended direction is greater than the available fixed correction can rectify. Often accurate printing can be disrupted by climatic changes where wrapping materials sensitive to moisture or temperature variation are used.

2. A missing or poorly contrasting registration mark may cause over correction and temporary visible displacement of the graphic design on the final product.

3. The positioning of the photoelectric detector may have to be a significant distance (in terms of the individual wraps) from the point in the machine where the wrapper is cut from the continuous length for use. This is quite common because of the physical requirements of the wrapping mechanisms involved and where this is the case, a small but variable error in the length of the printed design causes, through a cumulative effect, considerable variation in the position of the design on the product.

All the failures described result in a quantity of inferior or wasted product. In the first case correction is usually made by stopping and resetting the machine and output is lost. In the third case either the wrapping material has to be rejected and replaced (with a loss of output and a material cost) or inferior product must be accepted.

This problem is inherent due to the fixed amount of adjustment which the known systems can provide such that when errors arise the machine can have difficulty trying to regain synchronism as it has to assume that the error is a certain value without having the intelligence to determine its value.

The present invention is directed to providing an arrangement more readily capable of coping with registration errors, and for reducing material losses.

The invention is characterised by means for computing the position error of the detected registration mark on each wrapper relative to the machine cycle and means for variably adjusting the feed mechanism to compensate for the error whereby the material arrives at the separating station at the correct point of time.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

FIGURE 1 shows an embodiment of the system of the present invention,

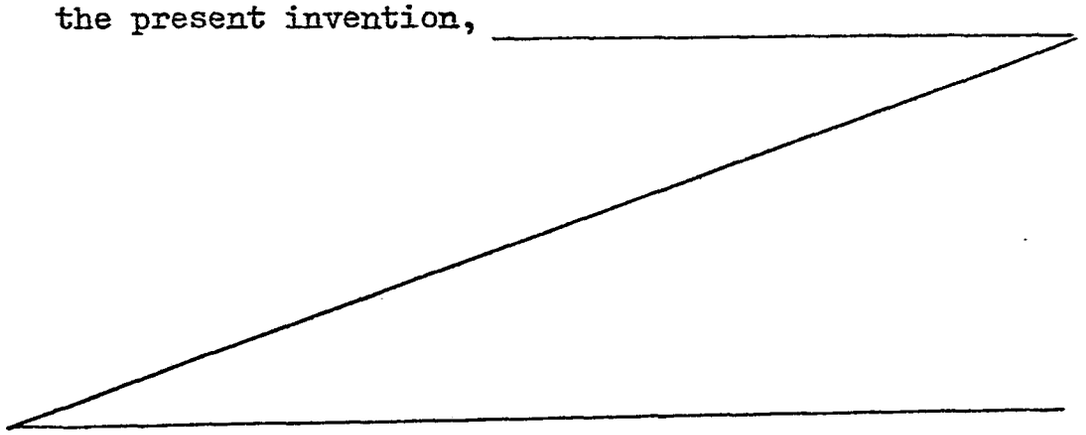


FIGURE 2 shows a simplified block diagram of the operation of the control system of Figure 1,

FIGURE 3 shows an embodiment of the control unit of Figures 1 and 2,

FIGURE 4 shows a timing diagram for the Figure 3 system operation, and

FIGURE 5 shows an expanded timing diagram for the start of a machine cycle.

In the Figure 1 embodiment the wrapping material 1 is in the form of a continuous strip and has registration marks 2 printed, one on each individual wrapper and each in the same relative position. The feed rollers 3 normally run at a constant speed to feed one wrapper per machine cycle to the separation station and the rotary knife 4 cuts the wrapper from the strip at the same moment relative to each machine cycle. A photoelectric detector 5 is positioned to inspect for the registration marks 2 as they pass through the machine. A coloured filter may be provided in front of the detector to enhance the contrast for detection purposes. The length of wrapping material delivered by the feed rollers 3, when no correction is applied by stepping motor 6, is defined as a feed pitch W. At the moment when the knife is cutting, the length of wrapping material lying between the registration mark 2 adjacent to the knife 4,

and the position of the photodetector 5, is arranged to be a whole number of feed pitches (represented by integer I in the formula below).

The feed rollers 3 are driven through the epicyclic gearbox 7 from the main drive shaft of the machine 8. Shaft 8 completes one revolution per machine cycle. The main drive shaft 8 is fitted with a cam driven switch 9 which is arranged to transmit a signal to the control unit 10 once per shaft revolution and with the rising edge of that signal coincident in time with the moment at which knife 4 cuts the wrapping material. Shaft 8 is also fitted with a pulse generator/11 which gives out a square waveform containing a fixed number of pulses per shaft revolution (represented by N in the formula below). The motor 6 drives the planetary gear of the epicyclic gearbox 7 in order to advance or retard the position of the wrapping material as required to maintain the material in register this variable amount being computed within the control unit 10. The ratio of the motor drive is selected such that one step of the motor 6 causes a displacement of the wrapping material 1 in accordance with the following formula.

One step of displacement = $\frac{S}{N} \times \frac{W}{I}$

where N & I are as defined above; W is the feed pitch as defined above; S is the detected displacement of the registration mark 2 from the moment of cut-off indicated by switch 9, measured as the intervening number of pulses generated by 11, which gives rise to one step of motor 6.

Figure 2 shows the basic operation of the control system within control unit 10. The pulse generator 11 provides a fixed number of pulses per machine cycle (e.g. 256). The counter 20 is arranged to count the incoming pulses when permitted by control 21. The start and stop of the counter is dependent on the signals received by control 21 from photodetector 5 and synchronising switch 9. When the machine is running in synchronism (i.e. with the registration mark being at the correct point relative to the knife position) then signals from both devices will occur simultaneously so that start and stop of the counter will occur together so that no pulses are stored in counter 20.

In the situation where there is an error in synchronisation (say) where the mark arrives early relative to the machine cycle then photodetector 5 will cause the counter to start counting via control 21 and the number of

pulses which occur before the counter stops under the control of the sync pulse from switch 9 will be indicative of the amount of error that is present and requires correction.

This error is passed to the feed control adjuster 22 which provides the variable degree of adjustment to motor 6 to cause the necessary compensation to the feeding to be achieved before the wrapper arrives at the cutting station. Where the motor 6 is a stepping motor this can be achieved by either adjusting the frequency of the drive pulses (using a voltage controlled oscillator) when the stepping motor is directly driving the feed mechanism, or as in the Figure 1 arrangement by providing a burst of pulses to the motor to cause retarding of the feed mechanism.

In the situation where the registration mark arrives late at the detection point relative to the machine cycle then the counter will count the pulses from generator 11 which are received between the pulse from sync switch 9 and the pulse from detector 5. This can be indicated as a negative error to the feed adjustment via the control 21 which will know which of the pulses for 5 or 9 arrived first. The negative (or under) error is used by feed control adjuster 22 to cause variable retarding of the feed mechanism by the computed amount to cause correction of the registration error.

An example of the way in which the control unit 10 of Figure 2 can be realised is now demonstrated in Figure 3.

The leading edge of synchronising pulse P from switch 9 is detected by rising edge detector block 34 (e.g. a monostable) and causes a short duration pulse T to be generated (see Figures 4 and 5). The leading edge of pulse T is used as a control signal and passes via AND gates 38,40 or 41 to enable multiple AND gates 43 or 45 to pass the output from counter 32 to be held in latch 46 controlled via OR gate 44. AND gate 38 etc. will only be enabled at this time provided one bit latch 35 is in a set condition resulting from a detected registration mark detected by photodetector 5 during the preceding machine cycle. The pulse T is also received by further rising edge detector 37 via inverter 36. This generates a pulse Z and due to the inverter 36 this pulse will be delayed by the duration of pulse T. Pulse Z acts as a reset pulse and resets 8 bit counter 32 and latch 35, 48 and 51.

Following resetting of counter 32 and latch 35 the output of which controls the AND gate 30 via inverter 33, the logic conditions allow pulses from generator 11 to be counted in counter 32 via edge detector 31 until the arrival of the next registration mark. The arrival of a pulse from photodetector 5 causes latch 35 to be set and provides a disabling pulse to AND gate 30 via inverter 33.

The counter output is indicative of the error and this count is passed to the latch 46 on receipt of the next sync pulse, before counter 32 is reset.

In the situation where the registration mark occurs soon after the commencement of the cycle this is indicative that the feed requires advancing to eliminate this error and the error count is passed to latch 46 via gate 45 without modification.

The example in Figure 4 shows arrival of the photocell detecting pulse R after 64 units have occured during the cycle (i.e. 1/4 way through the cycle). The corrective action is shown being effected during the next cycle by the generation of 4 pulses for stepping motor 6 in the forward direction (as the 3 least significant bits have been ignored).

In the situation where the registration mark occurs towards the end of the cycle this is in fact indicative that the mark is arriving too soon for the next cycle and the feed requires retarding.

The amount required to be retarded is in practice (1-COUNT) and so the complement of the count is determined as explained below.

Thus when a registration mark is detected during the second half of a machine cycle, the pulse count is large enough by then to set the most significant bit of counter 32 and this is used to indicate that the wrapping material is to be retarded.

This MSB is passed via inverter 39 to disable AND gate 41 so that the counter output is passed via gate 43 rather than gate 45.

Inverters 42 complement the count and one bit latch 51, AND gate 52 and edge detector 53 increment the count by one to give the true value of displacement, due to the MSB from gate 47.

The setting of latch 51 is indicative of the direction of correction required. The output from latch 51 controls AND gate 59 to allow retarding of the feed. The inverted output from latch 51 via inverter 58 controls the advance of the feed via AND gate 60.

The setting of latch 48 dependent on the counter 32 output allows corrective action via inverter 50 to be provided other than close to the time of cutting. The output from latch 48 is also used via rising edge detector 49 to enable gate 47 so that the error count is made available to counter 54 (Modified as necessary). The motor 6 will start to run as commanded by the output from AND gate 55 driving the oscillator 61 and controlling AND gate 56.

Each time a pulse is transmitted to the motor, counter 54 is decremented by one via OR gate 62, inverter 63 and rising edge detector 64.

When the counter 54 output becomes zero the corrective action will cease.

When a registration mark is not detected during a machine cycle the position of the most recently detected mark is used to determine the correction to be applied. It is most convenient for the nominal length of a wrapper

to be marginally different from the feed pitch. This difference is not important when more complex control systems are used.

Although the system has been described as incorporating a pulse generator 11 driving the counter, this would be modified to a system operating on a time basis whereby the error is measured as a time error for a given cycle and correction is effected on a time basis.

Although the system has been illustrated as using a control unit using dedicated hardware, a microprocessor based system could equally be used and this would allow greater flexibility of operation and would be readily suited to a real time control using its internal clock generator and arithmetic unit to compute the error and control the correction required.

The algorithm can be such as to compensate for non-sighting of registration marks and similar modes of potential failure.

The system could be modified to accept signals from the photodetector only at predetermined periods during the cycle. This allows the conventional use of a 'window' in the printed design should such an approach be necessary for machine design purposes.

Thus the system of the invention responds proportionally to the magnitude of the apparent positional error by calculating the appropriate correction to the wrapper position during every machine cycle so that

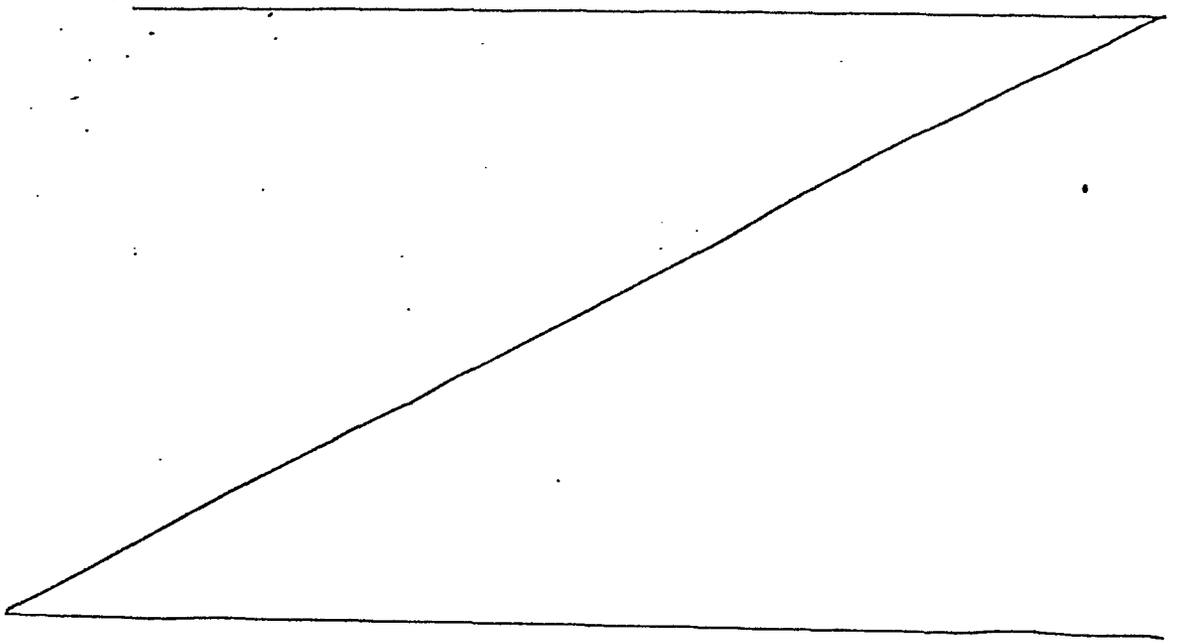
wastage of material due to incorrect registration is substantially avoided.

The system is capable of coping both with continuously fed and intermittently fed wrapping material when incorporated in machines operating in this manner.

In the latter situation feeding is provided only during part of the machine cycle, but correction can be effected in a similar manner to the continuously fed system.

With the present correction systen, changes in wrapper length can be more readily accommodated without the need to continually change the diameter or gearing of the feed rollers. Thus different batches of wrapping material may have varying nominal dimensions which can be accommodated by the system handling this difference as a constant error computed with any additional operational error.

Further, where a change in feed gear ratio or roller size is required when dealing with different products, the selected size or ratio need only be approximate, as the system is capable of handling this constant error when computing the total error. Thus selecting precise ratios or machining of the rollers is avoided.



Although the registration has been described in terms of a visible mark separate from the printed design, the mark could alternatively form part of the wrapper design (i.e. pattern recognition). Indeed the mark only requires the ability to be scanned and detected visually or otherwise by a suitable sensor.

In the embodiment descibed the correction is effected according to the average error over a number of wraps between photodetector and knife and this allows the possibility of continued operation even if a mark is occasionally missed by the detector.

In an alternative embodiment, the individual errors for each wrap could be temporarily stored in sequence in latches and used to compensate by incrementing/ decrementing the feed on a wrap by wrap basis as each approached the cutter position.

Because the system computes the error on each wrapper, the system is able to cope with extreme variations in feed speeds. Indeed the system can cope with correction of registration from machine start up until full speed is reached once the first wrapper has been detected and thus the complications associated with machine start up are substantially reduced.

Also material build up on the rollers is easily compensated for by the present system.

CLAIMS:

1. A wrapper feed control system having a feed mechanism (3) for feeding to a separating station (4) continuous wrapping material of the type carrying a registration mark and including means (5) for detecting the presence of each registration mark on said material, characterised by means (10) for computing any position error of the detected registration mark on each wrapper relative to the machine cycle and adjustment means (6) for variably adjusting the feed mechanism to compensate for the error whereby the material arrives at the separating station at the correct point in time.

2. A system as claimed in Claim 1, characterised in that said computing means includes determining means (20) for generating an error signal proportional to the relation between the detected signal and the machine cycle and means (21) for evaluating whether the error requires correction by incrementing or decrementing the feed mechanism.

3. A system as claimed in Claim 2 characterised by synchronising means (9) for producing a reference signal at a predetermined point in the machine cycle.

4. A system as claimed in Claim 3, characterised by pulse generator means (11) for generating a plurality of pulses during each machine cycle at a rate dependent on said cycle and said determining means includes a counter (2) for counting pulses in the period between the arrival of said reference signal and the detector

signal or vice versa.

5. A system as claimed in Claim 4, characterised in that said evaluating means includes a logic control circuit (21) for evaluating whether the reference signal or the detector signal arrives first in a given machine cycle to establish whether incremental or decremental correction is required.

6. A system as claimed in any one of Claims 1 to 5, characterised by memory means (46) for holding the computed error for use by the adjustment means.

7. A system as claimed in Claim 6, characterised by inhibiting means (38, 41, 44) for preventing updating of the memory means whenever a registration mark is undetected during a given machine cycle to retain earlier compensation information.

8. A system as claimed in any one of Claims 1 to 7 characterised in that the feed mechanism includes first drive means (8) for driving the feed mechanism and said adjustment means includes an auxiliary drive means (6, 7) for intermittently applying a variable factor to the feed drive.

9. A system as claimed in Claim 8, characterised in that said auxiliary drive means includes a motor (6) and said computing means includes an oscillator (61) for producing a train of signals operable to actuate said motor to correct the feed error.

10. A system as claimed in Claim 9, characterised by control means (58, 59, 60) for controlling the direction of rotation of said motor in dependence on whether incremental or decremental correction is required.

11. A system as claimed in any one of Claims 1 to 10 characterised in that said computation means is adapted to compute an average error over a plurality of machine cycles corresponding to the number of pitches between the detector means and the separating station.

12. A system as claimed in any one of Claims 1 to 11 characterised in that the computation means is adapted to compute the error on a time basis.

13. A system as claimed in any one of Claims 1 to 12 characterised in that the computation means includes a microprocessor.

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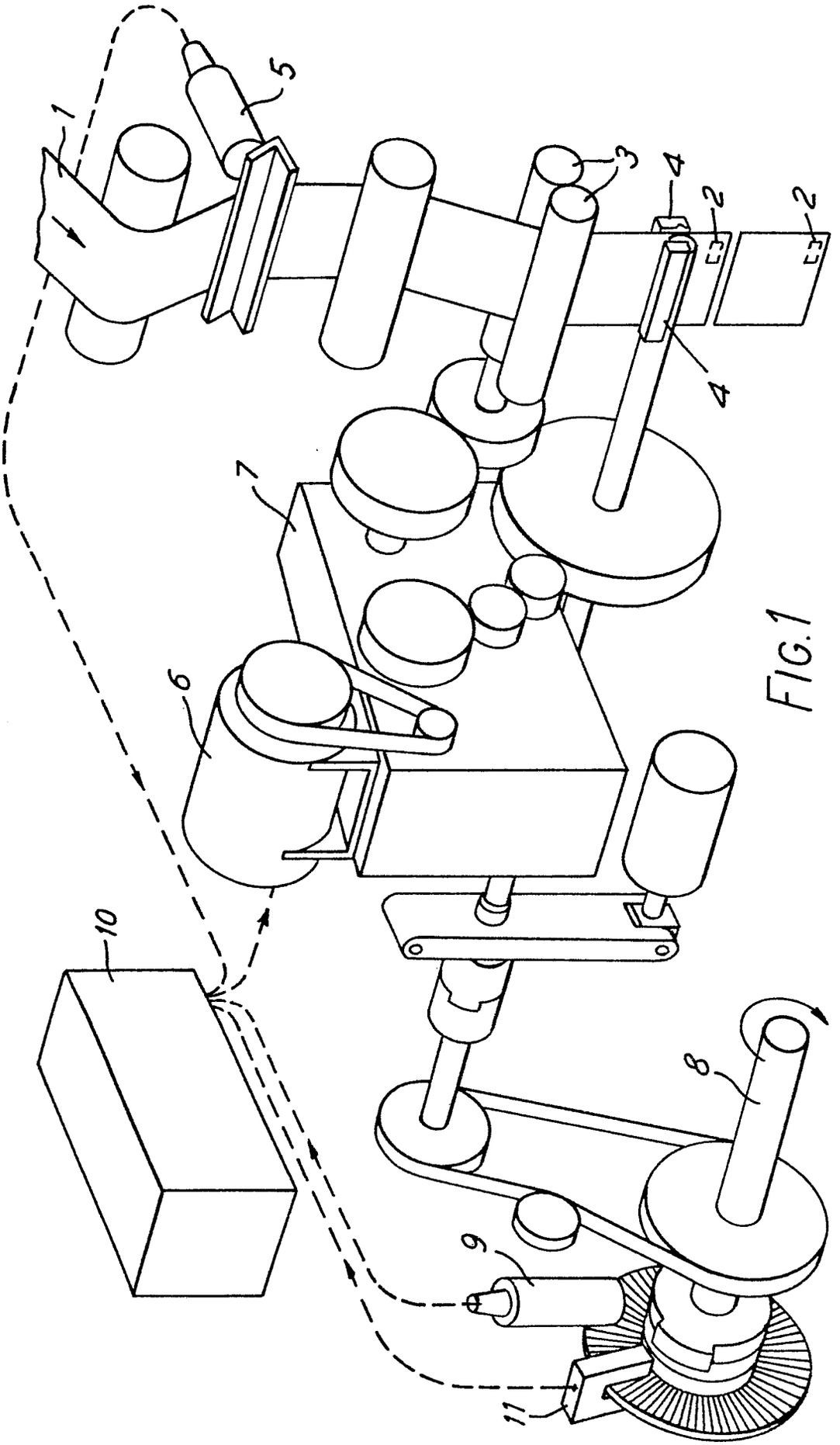

FIG.1

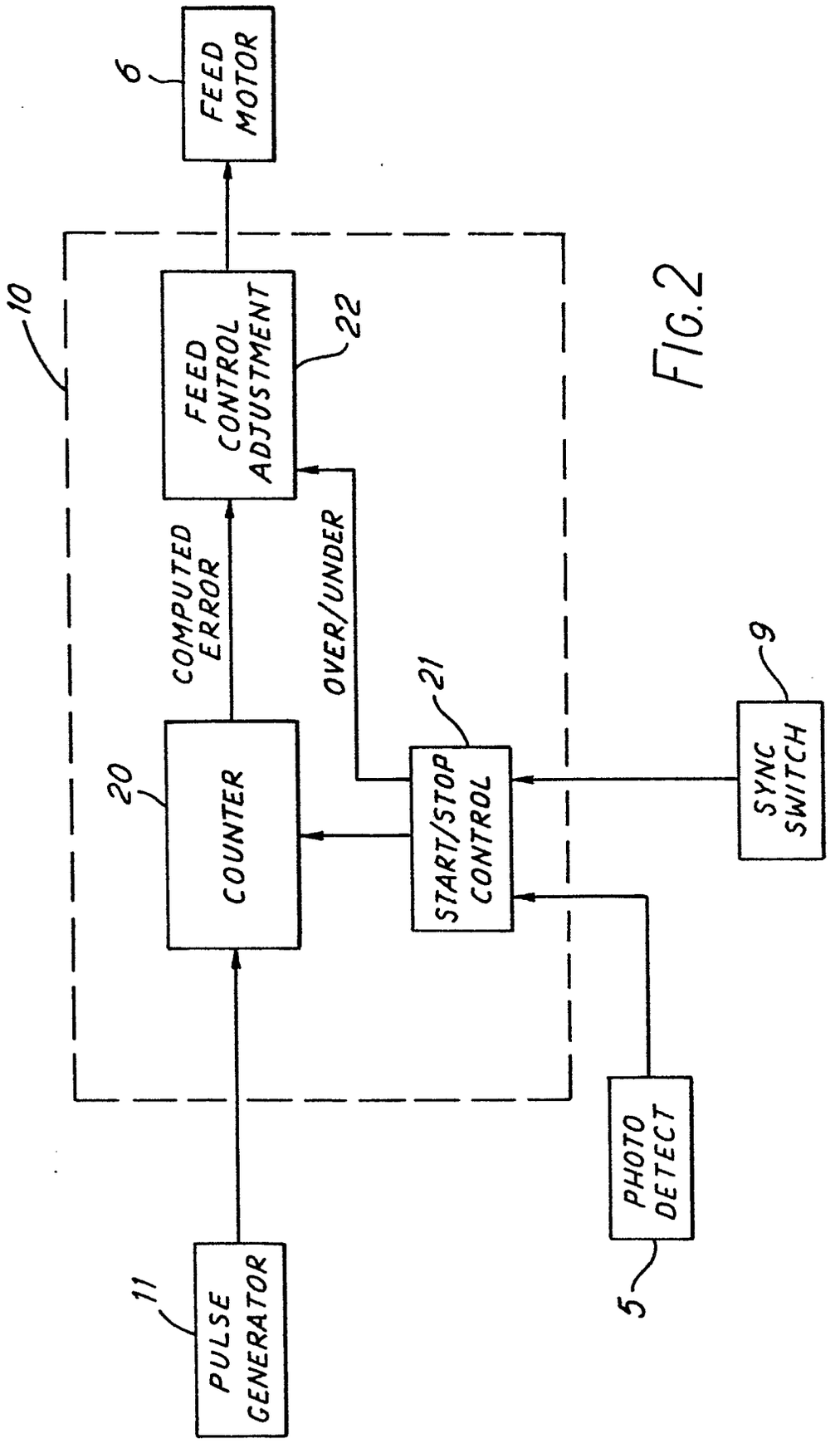
6
FEED MOTOR
10
FEED CONTROL ADJUSTMENT
22
COMPUTED ERROR
OVER/UNDER
20
COUNTER
21
START/STOP CONTROL
9
SYNC SWITCH
11
PULSE GENERATOR
PHOTO DETECT
5

FIG. 2

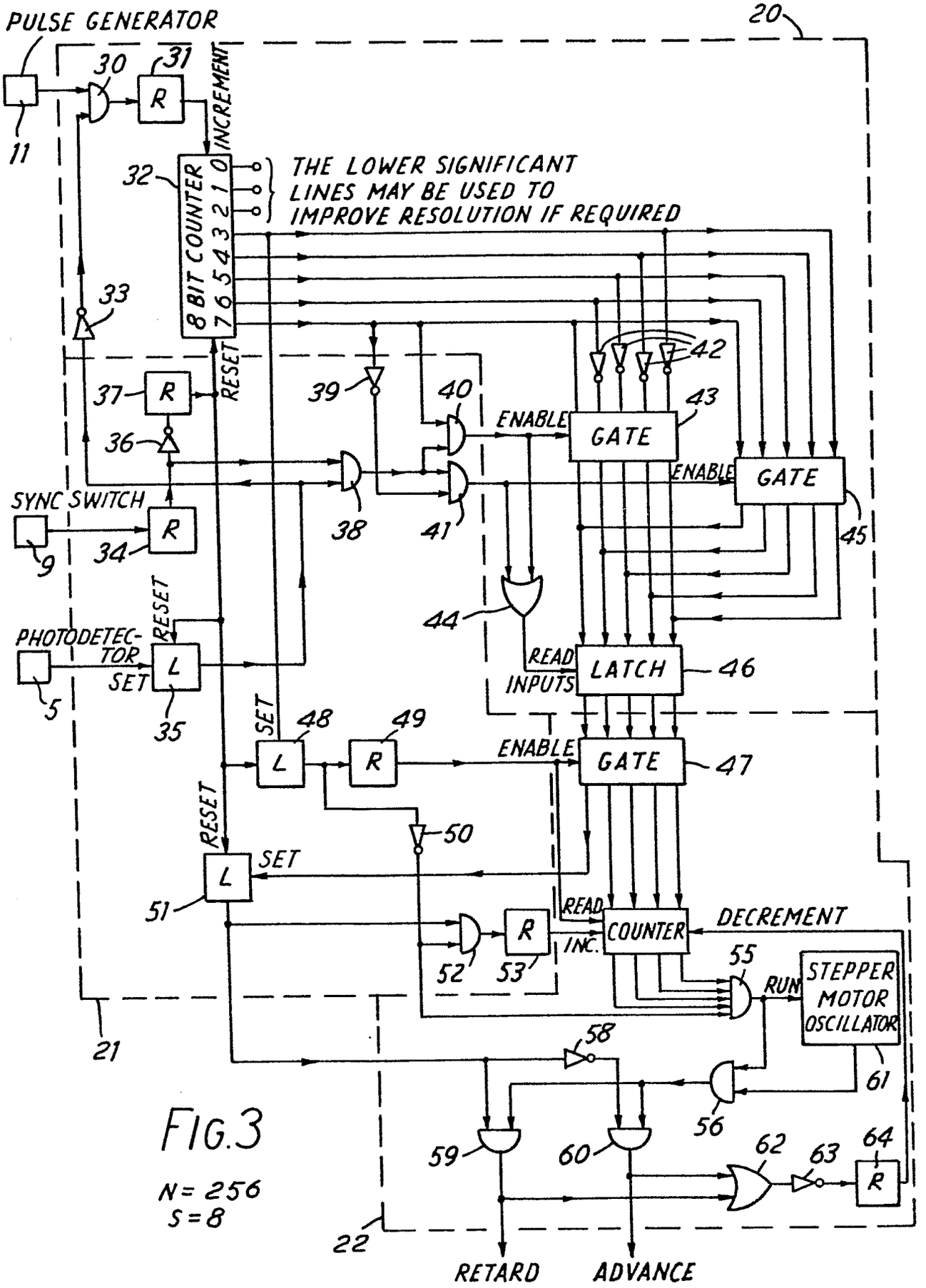
PULSE GENERATOR
20
11
30
31
R
INCREMENT
32
8 BIT COUNTER
7 6 5 4 3 2 1 0
THE LOWER SIGNIFICANT LINES MAY BE USED TO IMPROVE RESOLUTION IF REQUIRED
33
RESET
37
R
36
39
40
42
43
ENABLE
GATE
ENABLE
GATE
45
SYNC SWITCH
9
34
R
38
41
44
RESET
PHOTODETEC-TOR
5
SET
L
35
READ INPUTS
LATCH
46
SET
48
L
49
R
ENABLE
GATE
47
RESET
50
L
SET
51
READ
R
INC.
COUNTER
DECREMENT
52
53
55
RUN
STEPPER MOTOR OSCILLATOR
61
21
58
56
59
60
62
63
64
R
22
RETARD
ADVANCE

FIG.3

N = 256
S = 8

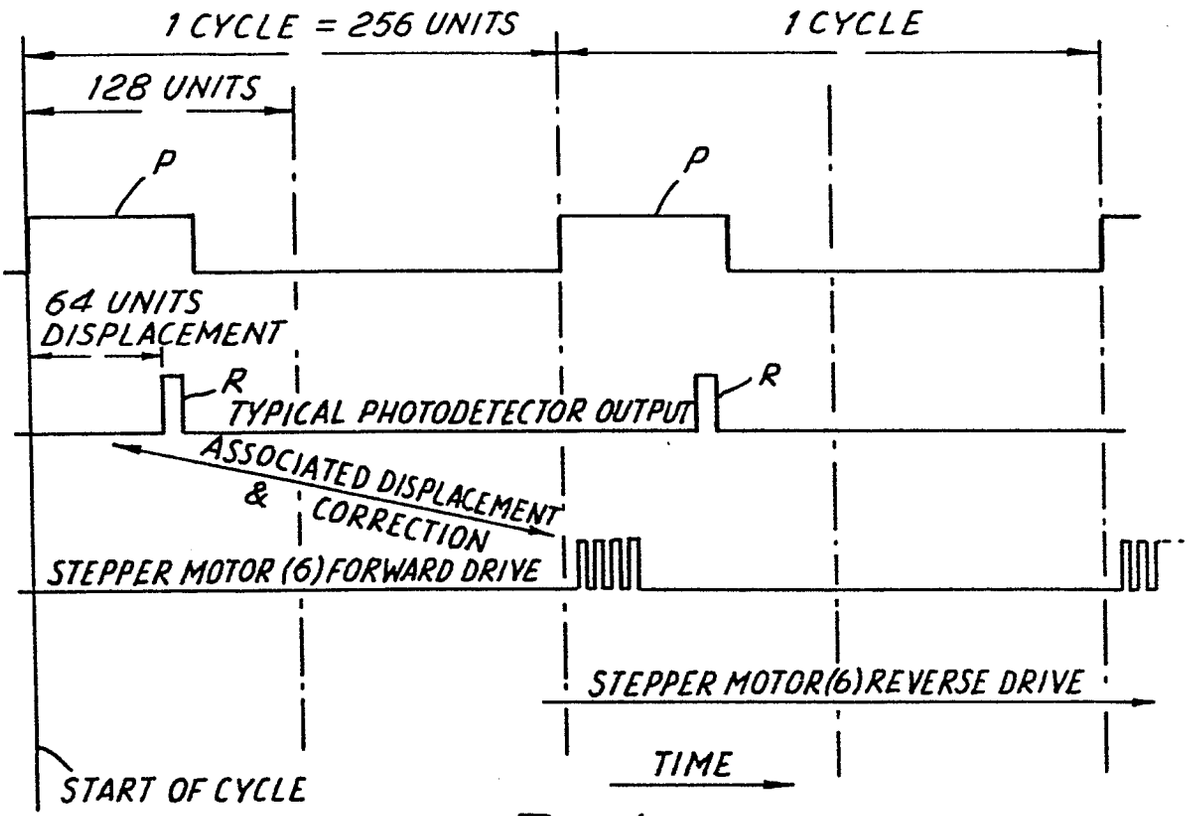
1 CYCLE = 256 UNITS
1 CYCLE
128 UNITS
P
P
64 UNITS
DISPLACEMENT
R
R
TYPICAL PHOTODETECTOR OUTPUT
ASSOCIATED DISPLACEMENT
&
CORRECTION
STEPPER MOTOR (6) FORWARD DRIVE
STEPPER MOTOR (6) REVERSE DRIVE
TIME
START OF CYCLE

FIG. 4

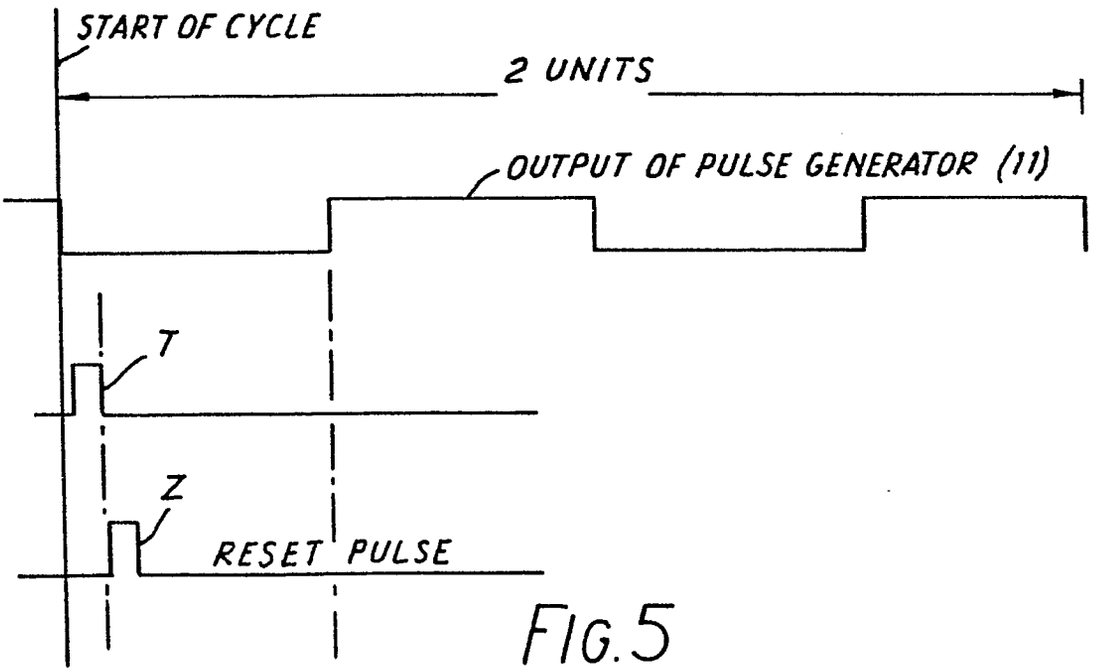
START OF CYCLE
2 UNITS
OUTPUT OF PULSE GENERATOR (11)
T
Z
RESET PULSE

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

0074165
Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 82303751.0

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
X	US - A - 3 774 016 (STERNS et al.) * Fig. 1-6B; column 4, line 12 - column 9, line 11 *	1-6,11	B 65 B 61/04// B 65 B 41/18 B 26 D 5/34
X	EP - A1 - 0 011 595 (SAPAL) * Abstract; fig. 2,5 *	1-5	
X	GB - A - 1 453 069 (BROWN & WILLIAMSON) * Claims; fig. 2,3,5B,8,9A,9A1 *	1-6	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

B 26 D 5/00
B 65 B 41/00
B 65 B 57/00
B 65 B 61/00
B 65 H 23/00

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	22-11-1982	MELZER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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