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Clarke

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[54] **DETECTION OF BLEMISHES ON SURFACES**

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[52] **U.S. Cl.** .... **318/640,** 250/219 DF

[51] **Int. Cl.** **G05b 1/06**

[58] **Field of Search** .... 318/640; 250/219 DF

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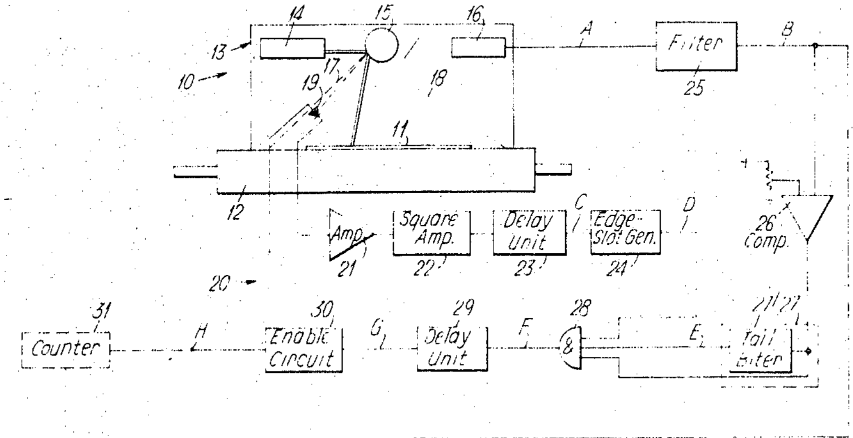
Attorney, Agent, or Firm—Cameron, Kerkam, Sutton, Stowell & Stowell

[57] **ABSTRACT**

A circuit arrangement for use with a detector of faults in a moving surface, the detector comprising a source of a beam of light caused to scan repetitively across the surface transversely to its direction of motion and detection means to collect light emanating from the surface to produce, in response to a change in the radiation collected, a fault signal. The circuit arrangement comprises means for generating an "edge slot" pulse which coincides with the engagement of the beam and the surface. The duration of the edge-slot pulse is chosen to ensure its existence at any engagement time allowing for unpredictable but limited movements of the edge of the surface. Fault counting is delayed until the edge of the surface (characterised as the first fault detected) is engaged by the beam during the presence of the edge slot pulse. This ensures that any signal received prior to the edge slot does not begin fault counting. The circuit may be modified to incorporate controls for the repositioning of the surface if it is engaged by the beam not during the presence of the edge slot pulse.

12 Claims, 8 Drawing Figures



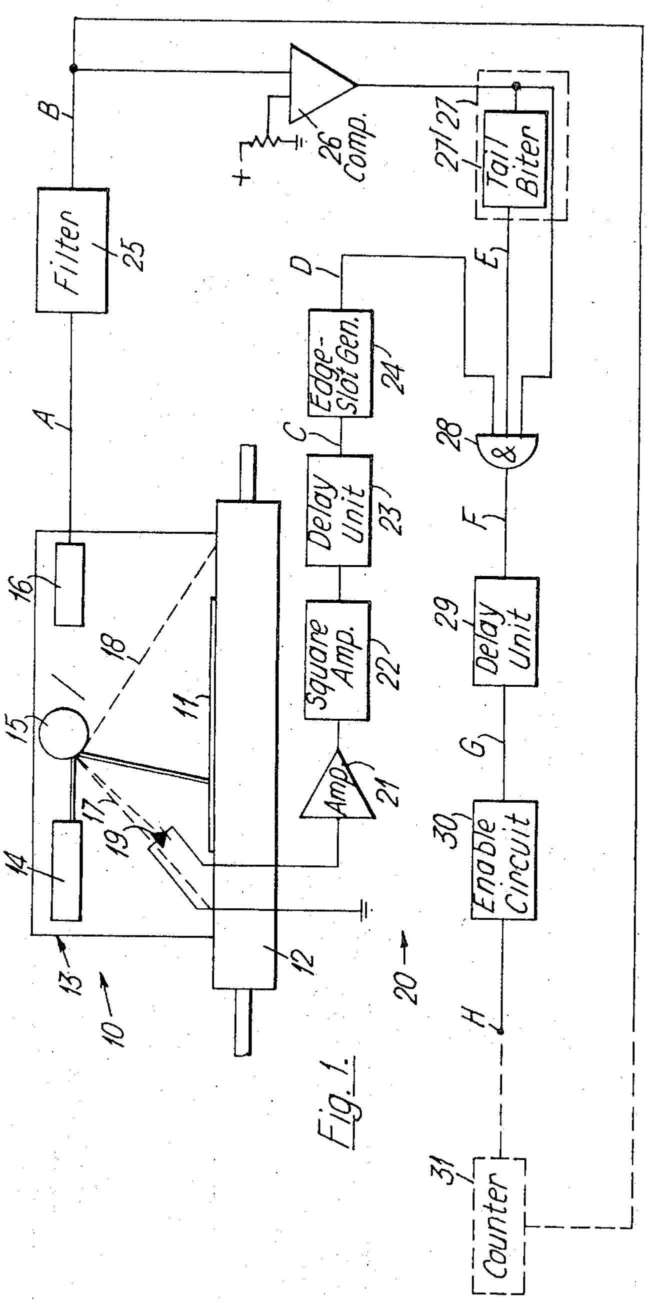

Filter
Comp.
Tail Biter
Edge-Slot Gen.
Delay Unit
Square Amp.
Amp
Delay Unit
Enable Circuit
Counter
&
+

Fig. 1.

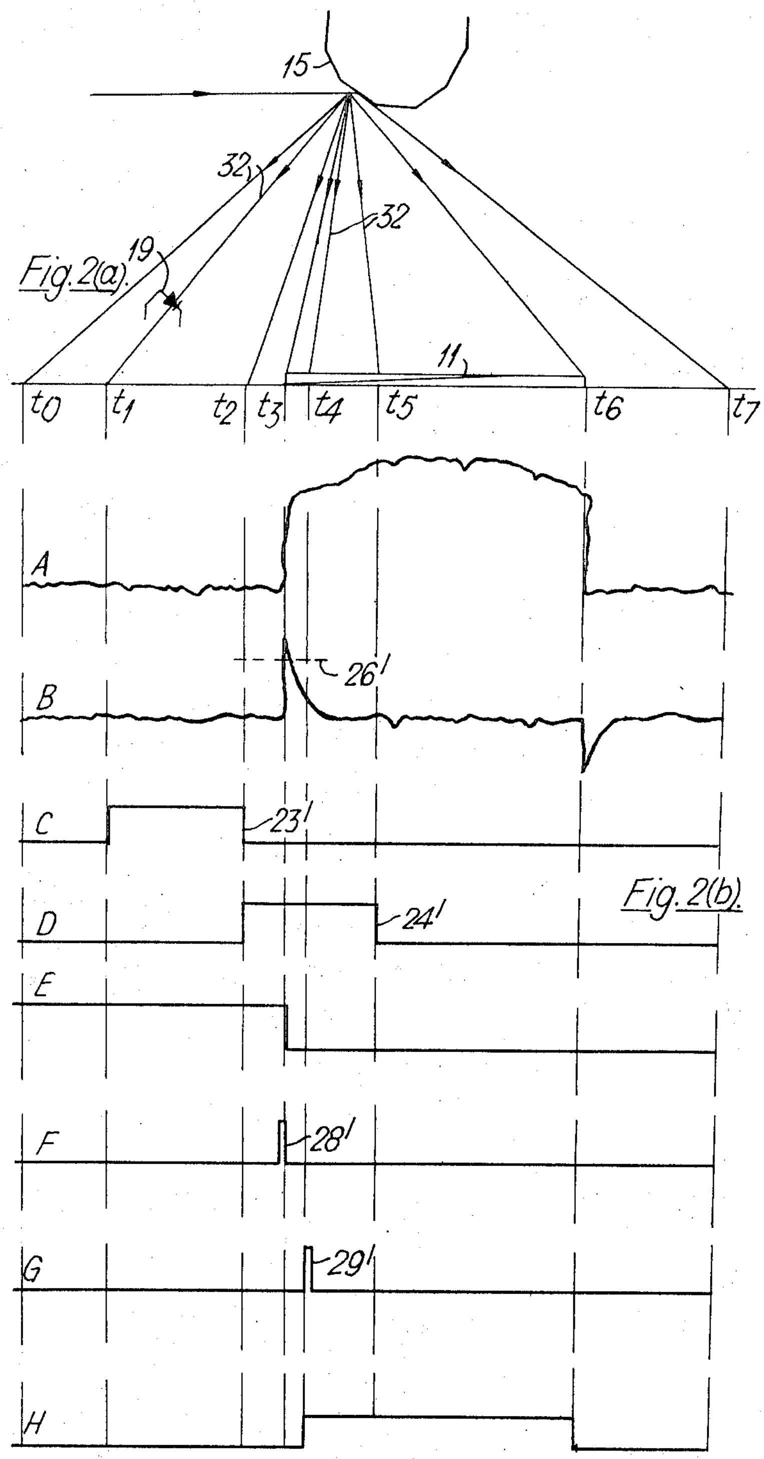
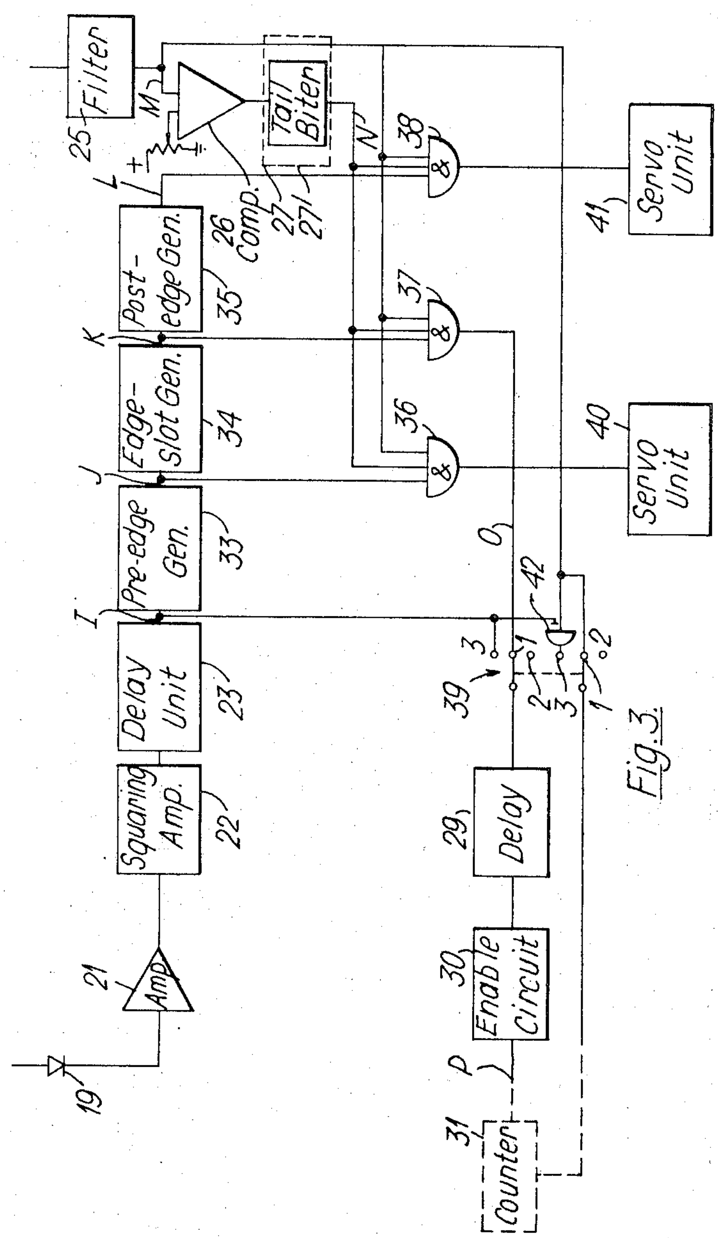


Fig. 2(a).

Fig. 2(b).


Filter
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Pre-edge Gen.
33
I
Delay Unit
23
Squaring Amp.
22
Amp
21
19
38
&
37
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36
&
Servo Unit
41
Servo Unit
40
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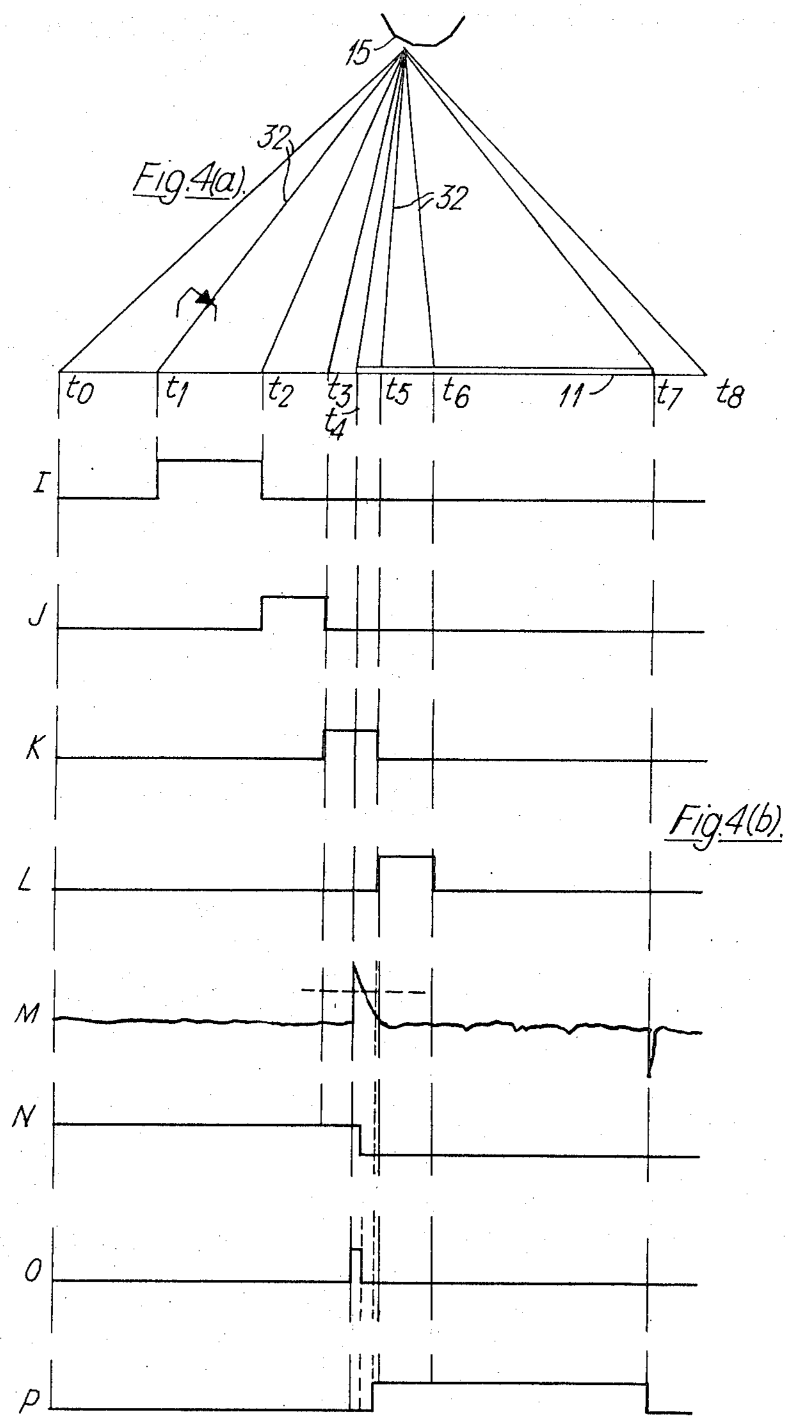
42
39
1
2
3
Delay
29
Enable Circuit
30
P
Counter
31

Fig. 3.


15
32
Fig.4(a).
32
t0
t1
t2
t3
t4
t5
t6
11
t7
t8
I
J
K
Fig.4(b).
L
M
N
O
P

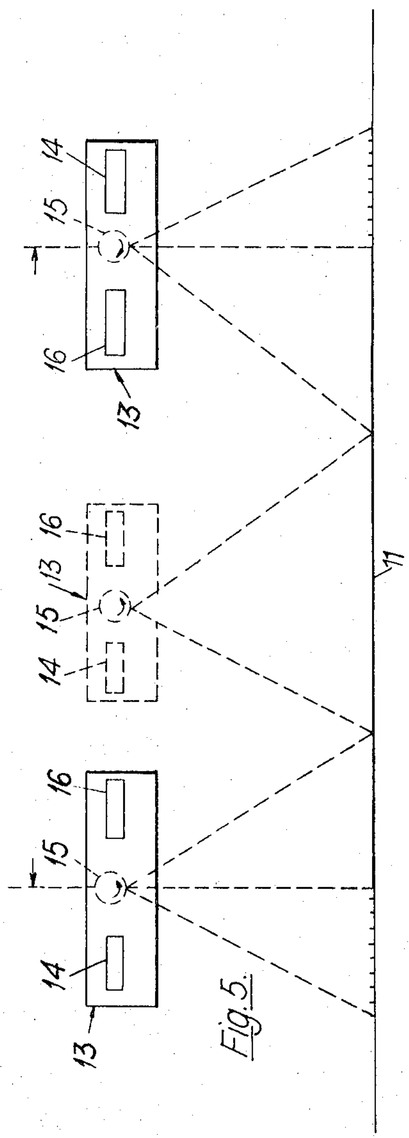


Fig.5.

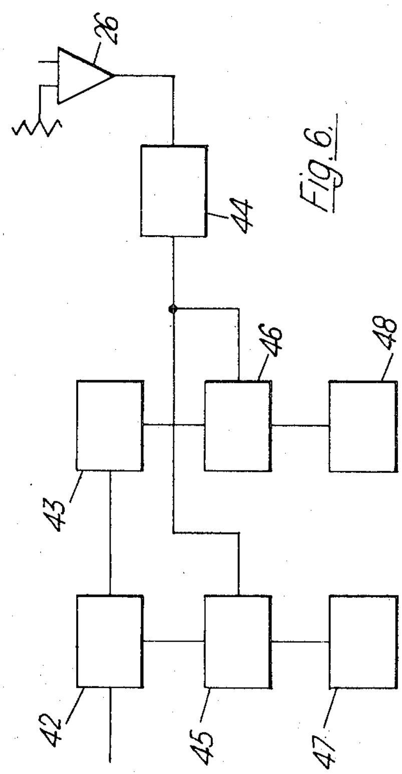


Fig.6.

DETECTION OF BLEMISHES ON SURFACES

This invention relates to the detection of faults on surfaces and in particular to circuit arrangements associated with such detection.

Detectors of faults are widely used in relation to moving strip-like surfaces such as those of paper webs, plastics material and steel. The particular type of detector with which this invention is concerned comprises a source of a beam of optical radiation, means to scan the beam repetitively across the surface transversely to the direction of motion of the surface and detection means to collect optical radiation emanating from the surface and to produce, in response to a change in the radiation collected, a fault signal. Such a detector of faults will hereinafter be referred to as being "of the type stated." The terms "optical radiation" and "light" are intended to include electromagnetic radiation of the visible, infra-red and ultra-violet parts of the spectrum.

This form of detector is adequate if the beam scans the surface exactly from edge to edge. However, it is unlikely that the surface will always be of sufficient width to completely fill the scan so that it is necessary to arrange means whereby any signals derived from reflections of the beam from the background and from the edge of the surface are not interpreted as faults. A typical solution has been to position a photo-diode such that it is crossed by the beam just as the beam is about to engage the surface; the photo-diode is used in a gate circuit to activate a counter of faults detected in the detection means for a predetermined period, that is, for the time taken for the beam to scan over the surface, so that only faults on the surface are counted.

Such a solution for gating the operation of the counter is not completely satisfactory in that the surface cannot be prevented from undergoing at least a small lateral movement. The maximum movement must be calculated and the operation of the fault counting means delayed until it is certain that the beam has engaged the surface. If the lateral movements of the surface are significant, then the margin for which counting does not take place may comprise an unacceptable amount of the surface.

It is an object of the present invention to provide improved fault detection for a detector of the type stated.

According to one aspect of the present invention a circuit arrangement for use with a detector of the type stated includes sensing means operable to detect the passage of the beam past a point to produce, in each scan, a timing reference signal, primary pulse means responsive to the timing reference signal to generate a primary pulse extending from some time before the beam engages a known discontinuity in the radiation absorbing properties of the surface until some time after the engagement, timing means responsive to the occurrence of a fault signal greater than a predetermined threshold value during the presence of the primary pulse to produce a counter enabling signal, and a counter, enabled by the counter enabling signal, to count subsequent fault signals.

The circuit arrangement may also include secondary pulse means responsive to the timing reference signal for providing a plurality of secondary pulses, at least one immediately preceding and at least one immediately succeeding the primary pulse, switching means responsive to a fault signal greater than said predetermined threshold value during the presence of a secondary pulse to produce a servo error signal, and servo control means responsive to said servo error signal to cause the surface to be moved substantially parallel to the line of scan of the beam until said fault signal is detected during the presence of the primary pulse.

According to another aspect of the present invention a detector of the type stated includes a circuit arrangement as defined in one or both of the two preceding paragraphs.

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

FIG. 1 is a schematic representation of a scanning fault detector and a circuit arrangement according to the present invention,

FIG. 2(*a*) illustrates the angular position of the scanning beam at various times into the scan,

FIG. 2(*b*) shows waveforms of signals at various points in the circuit of FIG. 1 in relation to the time scale of FIG. 2(*a*),

FIG. 3 is a modified form of the edge detection circuitry of FIG. 1,

FIGS. 4(*a*) and 4(*b*) correspond the FIGS. 2(*a*) and (*b*) but relate to FIG. 3,

FIG. 5 shows a modified form of scanning arrangement, and

FIG. 6 shows an alternative form of part of the circuit arrangement of FIG. 3.

With reference to FIG. 1, the part 10 of the Figure shows a section of a continuous web 11 of paper or other material which is caused to move continuously over a roller 12 in a direction perpendicular to the plane of the drawing. A detector of faults includes a scanning station 13, mounted over the web as it crosses the roller 12, and containing a source of a beam of optical radiation 14, a multi-faceted mirror 15 and a photomultiplier detection means 16. Optical radiation, or light, from the source 14 is emitted in a beam such that after reflection at a facet of the mirror, the beam converges to illuminate a small area on the roller 12 or on the surface of the web 11. The mirror 15 is rotatable about its axis so that the light beam is caused to scan along the axis of the roller 12, and transversely across the moving web 11, as each facet of the mirror rotates relative to the incident beam. The beam moves between limits shown by the broken lines 17 and 18. The surface of the roller 12 is treated to make it generally non-reflecting of the light. For a use in which the web is generally non-reflecting, then the roller is made reflecting so that similar signals, but of opposite polarity, are detected.

Sensing means, in the form of a photo-diode 19 is placed in the path of the beam at some convenient point near the start of the scan to produce a timing reference signal for subsequent circuit functions. Light that is reflected from the roller and light reflected from the web is collected in the photomultiplier detection means 16 and any fault signal obtained therefrom is passed to the remainder of the circuit arrangement indicated at 20.

The output of the photo-diode 19 is fed to primary pulse means. This includes an amplifier 21 and a squaring amplifier 22, whereby a rectangular pulse is produced near the beginning of each scan. The squaring amplifier conveniently produces a pulse of known amplitude. The falling edge of the pulse triggers an adjustable delay unit **23.** The unit may take any convenient form but is shown as a pulse generator. The duration of the generated pulse is adjusted in accordance with the approximate width of the web so that it ends at a time just prior to that at which the beam is expected to engage the edge of the web. The falling edge of the delay pulse triggers an "edge slot" pulse generator **24.** The edge slot generator produces a primary pulse of predetermined duration which extends until a time at which the beam must have engaged the web, for any likely position of the edge. The edge slot, (primary), pulse is thus generated in response to the timing reference signal, the adjustable delay unit **23** varying the position of the edge slot pulse into the scan in order to accommodate different web widths.

Fault counting is begun when the edge of the web is detected within the edge slot, that is, during the presence of the edge slot pulse, so that faults are counted after the edge is detected and not after an arbitrary period as in previous arrangements. The output of the photomultiplier detection means **16** is passed through a high-pass filter **25** to remove any d.c. component of the signal and then to a comparator **26.** The sudden change in the amount of light reflected as the beam engages the web creates a large input signal, and the comparator output is dependent on the input signal being above the threshold value chosen to exclude pulses other than the large "edge" pulse. The output of the comparator **26** is fed to a "tail-biter" circuit **27.** The tail-biter circuit **27** includes a bistable circuit **27′** which gives a normally positive output that is reduced to zero or a negative value when a positive input signal is applied; the change in output is delayed for a very small period of time, say, **20** nano-seconds after the input is applied. The tail-biter is defined as a circuit arrangement in which the output comprises the original input signal existing for a short period of time after the application of the input signal. The output is fed to the inputs of a three-input AND-gate **28.** Thus irrespective of the subsequent output state of the comparator **26,** the effective input to the AND-gate **28** from this tail-biter source occurs only for **20** nano-seconds after the start of the signal. The third input to the AND-gate is the primary pulse from the edge slot pulse generator **24.** The output of the AND-gate **28** will therefore only be a positive pulse of **20** nano-second duration if the beam image crosses the edge of the web during the period of the edge slot. The output signal from the AND-gate **28** is fed, by way of an optional delay unit **29,** to a counter enabling pulse generator **30.** The generator **30,** upon receipt of the AND-gate pulse, generates a pulse of duration equal to the time taken for the beam image to cross the known width of the web. The tail-biter **27,** AND-gate **28,** delay **29** and generator **30** comprise timing means. This pulse permits a counter **31** to function only while the pulse is present. Fault signals are fed directly from the output of the filter **25** to the input of the counter **31.** The use of the delay unit **29** and the relationship between the circuit operations may be explained with reference to FIGS. **2**(*a*) and **2**(*b*).

In FIG. **2**(*a*) the lines **32** indicate the positions of the incident beam at times t_o to t_7 and the waveforms A to H of signals appearing at the points labelled A to H in the circuit at corresponding times are shown in FIG. **2**(*b*).

The waveform of the output signal of the photomultiplier detection means is shown at A in FIG. **2**(*b*) for one complete scan. The waveform is characterised by a step corresponding to each edge of the web. The waveform B shows the form of the detected signal after passage through the high-pass filter **25** and in which the step at each edge has been replaced by a "spike" pulse of much greater amplitude than the intermediate fault pulses. The comparator **26** acts to pass only points of the signal above the threshold value shown in waveform B at **26′**.

With reference to FIGS. **2**(*a*) and **2**(*b*), the beam commences its scan at time t_o. At a time t_1 the beam crosses the photo-diode **19** of the sensing means, actuating the delay unit **23** to initiate the delay pulse shown at **23′** in the waveform C of FIG. **2**(*b*). At the end of the delay period, at a time t_2, the delay pulse **23′** falls to zero and the edge slot generator **24** is triggered producing a positive output pulse **24′** for a preset period lasting until a time t_5, as shown in waveform D. The output then returns to zero for the remainder of the scan.

The beam engages the web at a time t_3, between t_2 and t_5. The output of the bistable circuit **27′** in the tail-biter circuit **27** is depicted in waveform E, the level falling to zero at a time t_4 shortly after the fault pulse representing the edge has been detected. The waveforms B, D and E are combined in the AND-gate **28** producing the output pulse **28′** of the waveform F. If the fault counting circuit was activated in response to the pulse **28′** of waveform F then the falling edge of the edge pulse below the level indicated at **26′** would be detected as a fault. The output of the AND-gate is delayed in the delay unit **29** until a time t_4 when the edge pulse of waveform B has fallen to a low value, and is then passed as a pulse **29′** — see waveform G — to the counter enabling generator **30.** The counter enabling generator produces an output pulse, as shown as waveform H, of duration equal to the time taken for the beam to cross the known width of the web and which lasts until a time t_6. The scan ends at a time t_7.

The circuit arrangement **20** as described may be modified to supply information on the position of the edge of the web to a servo control system whereby the web may be accurately positioned for trimming or printing.

A modified form of the circuit of FIG. **1** is shown in FIG. **3.** A scan timing reference signal is detected by the photo-diode **19,** amplified and fed as a rectangular pulse into an adjustable delay unit **23.** The delay unit **23** provides a rectangular pulse of adjustable duration. The falling edge of the delay pulse triggers a first pulse generator **33** producing a secondary, or "preedge" pulse, that is, a pulse which ends before the beam engages the web. The falling edge of this pulse triggers a similar generator **34** comprising the primary pulse generator which produces a shorter edge slot pulse, equivalent to the primary pulse of the previous embodiment, that should be present as the beam image crosses the edge of the web. A second pulse generator **35** produces a further secondary pulse, a "post-edge" pulse, of similar duration to the pre-edge pulse upon being triggered by the falling edge of the edge slot pulse.

The output of each of the pulse generators **33, 34** and **35** is fed to switching means and in particular to one input of AND-gates **36, 37** and **38** respectively. The other inputs are common to each gate and comprise the output of the tail-biter circuit **27.**

The output of the AND-gate 37 is fed by way of a switch 39 to the delay unit 29, counter enabling generator 30 and counter 31 described for FIG. 1. The switch 39 is a three position double-pole switch and is normally in the (centre) position 1. The outputs of AND-gates 36 and 38 are fed respectively to servo control means 40 and 41.

The operation of the circuit will be described with reference to FIGS. 4(*a*) and 4(*b*). FIG. 4(*a*) is similar to FIG. 2(*a*) in that it represents the beam positions at time t_o to t_8 of one scan and the waveforms of FIG. 4(*b*) on the same time scale represent the signals at positions I to P in FIG. 3.

The beam begins to scan at a time t_o and crosses the photo-diode 19 at t_1, at which time the delay unit pulse 23' is triggered (waveform I). The duration of the pulse is adjustable but is shown as ending at time t_2. The pre-edge pulse, shown at 33' in waveform J, is triggered at the time t_2 and continues until time t_3. At time t_3 the edge slot pulse is generated (34' in waveform K) and continues until time t_5. At time t_5, the post-edge pulse is generated (35' in waveform L) which continues until time t_6.

Normally the web is positioned such that the beam image engages the web at a time t_4, between times t_3 and t_5, while the edge slot pulse is present. The beam leaves the web at a time t_7 and the scan ends at a time t_8.

The waveform M represents the detected signal (after filtering) and the threshold value 26' that above which the comparator 26 provides an output. The waveform N represents the output of the bistable circuit 27' in the tail-biter circuit 27. The signals having the waveforms L, M and N are fed into the AND-gate 37 which produces a short pulse output (37' in waveform O). After a suitable delay the pulse is used to trigger a pulse (waveform P) from the counter enabling generator 30.

The AND-gates 36 and 38 have no inputs from the generators 33 and 35 between the time t_3 and t_5 and so give no output. If, however, the web is displaced from its normal position, say to the left in FIG. 4(*a*), such that the beam crosses the edge of the web at a time between t_2 and t_3 then there will be no output from the AND-gate 37, but a pulse will be produced at the output of the AND-gate 36. The servo control system 40 will operate to move the web to the right so that on the next scan, the edge of the web will be detected during the edge slot pulse. Thus no fault count will be made unless the web is in the correct position.

Similarly, if the web has moved to the right in FIG. 4(*a*) then the edge will be detected during the post-edge pulse, that is, between times t_5 and t_6. Again there will be no output from AND-gate 37, but AND-gate 38 will supply a pulse to the servo control system 41 and the web will be moved to the left.

In a "bang-bang" servo system, that is, one which is fully correcting in each direction independently of displacement, the edge slot is required to prevent the servo system hunting about the correct position.

In an alternative arrangement shown in FIG. 6 the pre-edge and post-edge pulse generators 33 and 35 are replaced by clock pulse generators 42 and 43 respectively each capable of emitting a predetermined number of clock pulses. The edge slot generator is not required as far as the positioning mechanism is concerned, that is, no dead-band is required, and is omitted from the circuit as shown.

A fault signal greater than the level set by the comparator 26 is used to trigger gate control means comprising a pulse generator 44. The generator produces a pulse which extends for a period of time in excess of the sum of the clock pulse generator emitting periods of the clock generators 42 and 43, and is fed to an input of each of the gates 45 and 46.

The trains of clock pulses are fed to gates 45 and 46 which have outputs connected to the triggers of monostable circuits 47 and 48 respectively such that a train of clock pulses passed by either gate produces, from the associated monostable circuit, an effective d.c. output for the duration of the pulse train.

In operation the passage of the beam across the photo-detector 19 (not shown in FIG. 5) initiates a pulse, delayed until a time shortly before the beam is expected to engage the surface. The delayed pulse triggers the clock generator 42 which produces a train of clock pulses until the time when the beam is expected to engage the surface, after which the clock generator 43 produces a pulse train of equal duration.

As stated previously the train of clock pulses from the clock generator 42 are fed to the gate 45. If during the generating period the edge of the surface is detected then the output from the comparator 26 triggers the gate control generator 44 which produces an output pulse to open the gate 45. This permits passage of the pulse train to the monostable circuit 47 and the production of a d.c. output signal, which signal is used directly as a position servo driving signal to move the surface in the direction of scan of the beam. The signal lasts until the clock pulse train stops, that is, when the edge of the surface is in the desired expected position.

The clock pulse generator 43 produces a train of clock pulses immediately after the pulse train from generator 42 has ceased and the pulses are fed to gate 46. This gate is normally open but passage is inhibited by the output signal from the gate control generator 44. Thus if the edge is detected before its correct position none of the clock pulses from the generator 43 will reach the monostable circuit 48. If the edge is not detected the clock pulses reach the monostable circuit 48 and a d.c. signal for servo correction of the position of the surface is produced. This signal causes the surface to be moved in the opposite direction to the scanning beam until the edge is detected, when the generator 44 produces an output and inhibits formation of the servo signal. The edge slot no longer is essential to provide a servo dead-band so far as positioning of the web is concerned, but is still useful as an edge slot for controlling the commencement of fault counting, and may be made as short as desired.

The web positioning system as described may be used with advantage to position a web in relation to a pattern on the web, for example, when slitting a web parallel to the pattern, or some other known discontinuity in the light absorbing properties of the surface.

To adapt the circuit of FIG. 3 to such use, the switch 39 is retained in position 1. The delay of unit 23 is extended onto the web such that the pre-edge pulse becomes the "pre-pattern" pulse, the edge slot and edge slot pulse become the "pattern slot" and "pattern slot" pulse, and the post-edge pulse becomes the "post-pattern" pulse. Operation is as previously described with servo correction being undertaken each time that the pattern is detected other than during the pattern slot pulse. The AND-gate **37** and the fault counter may be retained and may be used to keep account of stability of the web position by counting the number of times that the pattern is detected within the pattern slot. If counting is not required then the switch **39** is moved to the (lower) position **2** to disconnect the counter **31** and the enabling generator **30.**

In the fault detection arrangement described for FIG. **3,** the fault counting may still be undertaken independently of the detection of the edge of the web. For such operation by the circuit of FIG. **3,** the switch **39** is moved to the (upper) position **3.** The enable circuit **30** is operated by the pulse of the delay unit **23** and effectively activates the counter **31** from the start of the scan. Counting, however, is inhibited for the duration of the delay pulse by a gate **42** so that "faults" are not counted until at least the pre-edge pulse is present. Thus all faults will be counted for all possible web positions and correction of the web position undertaken.

Edge triggering of the fault counting means described above in detail deals satisfactorily with the leading edge of the photomultiplier detector signal but not with the trailing edge because a constant web width is assumed. Variation in width of the web may lead to "faults" being detected from outside the web if it should decrease, or miss faults near to the edge if it should increase.

The trailing edge of the web may be detected in a manner similar to that employed for the leading edge in the circuit arrangements of FIGS. **1** and **3.** A photodiode (not shown), similar to the photo-diode **19,** is positioned in the path of the beam at some point near to the end of the scan and is used to trigger a delay pulse which extends until just before the trailing edge of the web is reached in the next scan. An edge slot pulse is then generated in the vicinity of the trailing edge, the associated circuitry (not shown) responding to the detection of a large negative going signal in this edge slot to stop the fault counting means **31.** A fresh delay pulse is triggered at the end of that scan. Alternatively, the trailing edge may be dealt with by having a scanning edge detector at each edge of the web and arranged to detect each edge as a leading edge. The principle of scanning the web at each edge may be adapted to the supply of web position signals and may be extended to measurement of the width of the web. With reference to FIG. **5,** the scanning mirrors **15** of each scanning station **10** may be placed an accurately known distance apart near each edge of the web **11.** The durations of the various pulses in the circuit are modulated according to the position of the mirror in the scan such that the position of the image, when detected, may be directly related to the rotational position of the reflecting mirror. Thus by relating the position of the detected web edge and the separation of the two scanning mirrors, the exact width of the web may be found for that particular scan.

Fault detection may be carried out simultaneously and the faults may be counted for defined regions near the web edges. If it is found that most of the faults occur in regions close to one or both edges, then the web may be slit along the one or both edges at such a width to bring the fault occurrence to within a tolerable limit.

All the above arrangements may be adapted, with suitable alterations to polarity of detected signal, for detection of faults by transmission of the beam through a transparent or partially transparent web.

What I claim is:

1. A circuit arrangement for use with a detector of faults in a moving surface, which surface is permitted to undergo limited displacement transversely to the direction of said movement, the detector comprising a source of a beam of optical radiation, means to scan the beam repetitively across the surface transversely to the direction of motion of the surface and detection means to collect optical radiation emanating from the surface to produce, in response to a change in the radiation collected, a fault signal, the circuit arrangement including sensing means operable to detect the passage of the beam past a point to produce, in each scan, a timing reference signal, primary pulse means responsive to each timing reference signal to generate a primary pulse which exists for the time taken by the beam to cross a region of permitted surface displacement within which region lies a discontinuity in the radiation absorbing properties of the surface, timing means responsive to the occurrence of a fault signal greater than a predetermined threshold value during the existence of the primary pulse to produce a counter enabling signal, and a counter, enabled by the counter enabling signal, to count subsequent fault signals.

2. A circuit arrangement as claimed in claim **1** in which the sensing means comprises a photodetector in the path of the beam at the start of the scan.

3. A circuit arrangement as claimed in claim **1** in which the timing means comprises a two-input AND gate arranged to have as inputs the primary pulse and the fault signal greater than a predetermined value, and a pulse generator arranged to be triggered by the AND gate to produce an output for a predetermined period of time.

4. A circuit arrangement as claimed in claim **3** which also includes a tail-biter circuit, as herein defined, in series with the fault signal input to the AND gate.

5. A circuit arrangement as claimed in claim **4** which also includes delay means between the AND gate and the pulse generator.

6. A circuit arrangement for use with a detector of faults in a moving surface, the detector comprising a source of a beam of optical radiation, means to scan the beam repetitively across the surface transversely to the direction of motion of the surface and detection means to collect optical radiation emanating from the surface to produce, in response to a change in the radiation collected, a fault signal, the circuit arrangement including sensing means operable to detect the passage of the beam past a point to produce, in each scan, a timing reference signal, primary pulse means responsive to the timing reference signal to generate a primary pulse extending from some time before the beam engages a known discontinuity in the radiation absorbing properties of the surface untilsome time after the engagement, timing means responsive to the occurrence of a fault signal greater than a predetermined threshold value during the presence of the primary pulse to produce a counter enabling signal, and a counter enabled by the counter enabling signal to count subsequent fault signals, secondary pulse means responsive to the timing reference signal for providing a plurality of secondary pulses, at least one immediately preceding and at least one immediately succeeding the primary pulse, switching means responsive to a fault signal greater than the predetermined threshold value during the presence of a secondary pulse to produce a servo error signal, and servo control means responsive to said servo error signal to cause the surface to be moved substantially parallel to the line of scan of the beam until said fault signal is detected during the presence of the primary pulse.

7. A circuit arrangement as claimed in claim **6** in which the secondary pulse means comprises a first pulse generator arranged to be triggered by said timing reference signal to produce a secondary pulse of predetermined duration and to cause, at the termination of said secondary pulse, operation of the primary pulse generator and the generation of said primary pulse, and a second pulse generator arranged to be triggered at the termination of said primary pulse to produce a further secondary pulse of predetermined duration.

8. A circuit arrangement as claimed in claim **7** in which the switching means comprises a plurality of AND gates, different AND gates being arranged to be supplied with different secondary pulses and all gates being arranged to be supplied with a fault signal greater than said predetermined value.

9. A circuit arrangement as claimed in claim **6** in which the secondary pulse means comprises a first clock pulse generator arranged to be operated by said timing reference signal to produce a predetermined number of secondary pulses and to cause, after the generation of the last pulse of said predetermined number, operation of the primary pulse generator and the generation of said primary pulse, and a second clock pulse generator adapted to be operated at the termination of said primary pulse to produce a predetermined number of further secondary pulses.

10. A circuit arrangement as claimed in claim **9** in which the switching means includes gate control means responsive to said fault signal to produce an output signal of predetermined duration, a first gate between the first clock pulse generator and the servo control means, said first gate being arranged to be opened by the output signal of the gate control means to allow passage to the servo control means of the remainder of the secondary pulses from the first clock pulse generator, and a second gate between the second clock pulse generator and the servo control means, said second gate being arranged to be closed by the output signal of the gate control means to prevent passage of the remainder of the secondary pulses from the second clock pulse generator to the servo control means.

11. A detector of faults in a moving surface, comprising a source of a beam of optical radiation, means to scan the beam repetitively across the surface transversely to the direction of motion of the surface, which surface is permitted to undergo limited displacement transversely to the direction of said movement, and detection means to collect optical radiation emanating from the surface to produce, in response to a change in the radiation collected, a fault signal, and a circuit arrangement including sensing means operable to detect the passage of the beam past a point to produce, in each scan, a timing reference signal, primary pulse means responsive to each timing reference signal to generate a primary pulse which exists for the time taken by the beam to cross a region of permitted surface displacement within which region lies a discontinuity in the radiation absorbing properties of the surface, timing means responsive to the occurrence of a fault signal greater than a predetermined threshold value during the existence of the primary pulse to produce a counter enabling signal, and a counter, enabled by the counter enabling signal, to count subsequent fault signals.

12. A detector of faults in a moving surface comprising a source of a beam of optical radiation means to scan the beam repetitively across the surface transversely to the direction of motion of the surface and detection means to collect optical radiation emanating from the surface to produce, in response to a change in the radiation collected, a fault signal and a circuit arrangement including sensing means operable to detect the passage of the beam past a point to produce, in each scan, a timing reference signal, primary pulse means responsive to the timing reference signal to generate a primary pulse extending from some time before the beam engages a known discontinuity in the radiation absorbing properties of the surface until some time after the engagement, timing means responsive to the occurrence of a fault signal greater than a predetermined threshold value during the presence of the primary pulse to produce a counter enabling signal, a counter, enabled by the counter enabling signal, to count subsequent fault signals, secondary pulse means responsive to the timing reference signal for providing a plurality of secondary pulses, at least one immediately preceding and at least one immediately succeeding the primary pulse, switching means responsive to a fault signal greater than said predetermined threshold value during the presence of a secondary pulse to produce a servo error signal, and servo control means responsive to said servo error signal to cause the surface to be moved substantially parallel to the line of scan of the beam until said fault signal is detected during the presence of the primary pulse.

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