United States Patent

Bhullar et al.

[15] **3,646,353**

[45] **Feb. 29, 1972**

[54] FLYING SPOT SCANNER BLANKING

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[73] Assignee: **Eastman Kodak Company,** Rochester, N.Y.

[22] Filed: **Oct. 19, 1970**

[21] Appl. No.: **81,969**

[52] **U.S. Cl.** .....**250/219 DF,** 356/200

[51] **Int. Cl.** **G01n 21/16**

[58] **Field of Search** .....250/219 DF, 219 WE; 356/200, 356/237, 238

[56] **References Cited**

UNITED STATES PATENTS

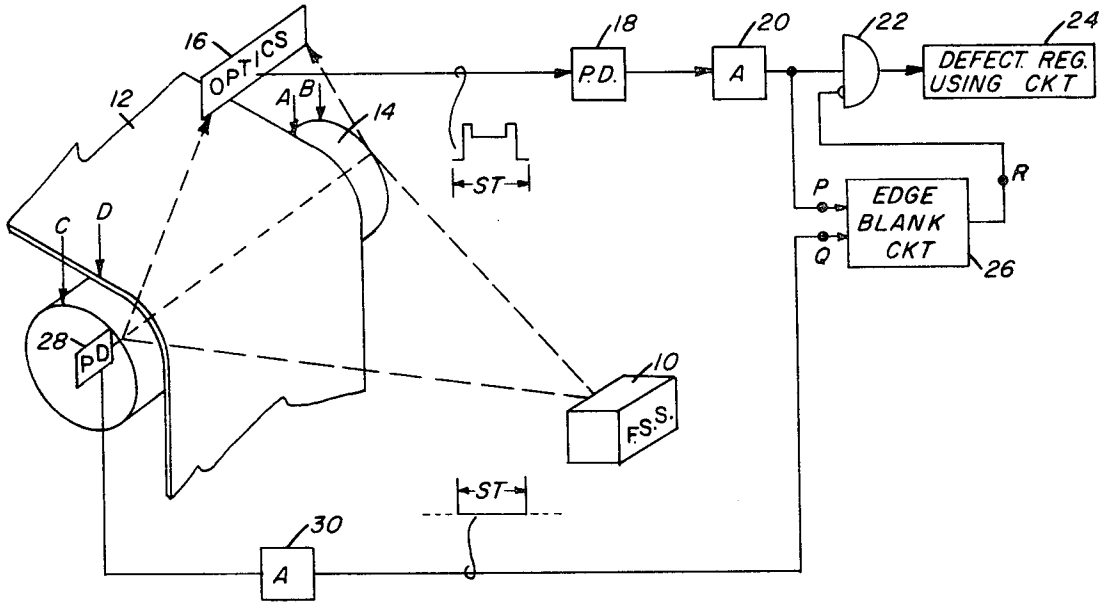
3,198,951	8/1965	Lentze	250/219 WE
3,360,651	12/1967	Linderman	250/219 DF
3,510,664	5/1970	Nichols	250/217 R

Primary Examiner—Ronald L. Wibert
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[57] **ABSTRACT**

A flying spot scanner is employed to inspect a web which rides over a supporting surface. Optical signals are produced at the edges of the web, and at the edges of the surface; and optical web defect signals are produced while scanning the web. To blank signals which are not web dependent, the invention proposes to split scan-produced signals into first and second halves thereof, whereby web-edge defining signals may be isolated, and employed to operate a blanking circuit. To prevent the registering of defects which are proximate the edges of the web, each pair of blank-defining signals produced during a given scan are shifted timewise to a subsequent scan, one of each such pair being shifted a little more, and the other of each such pair being shifted a little less, than a scan duration.

6 Claims, 8 Drawing Figures



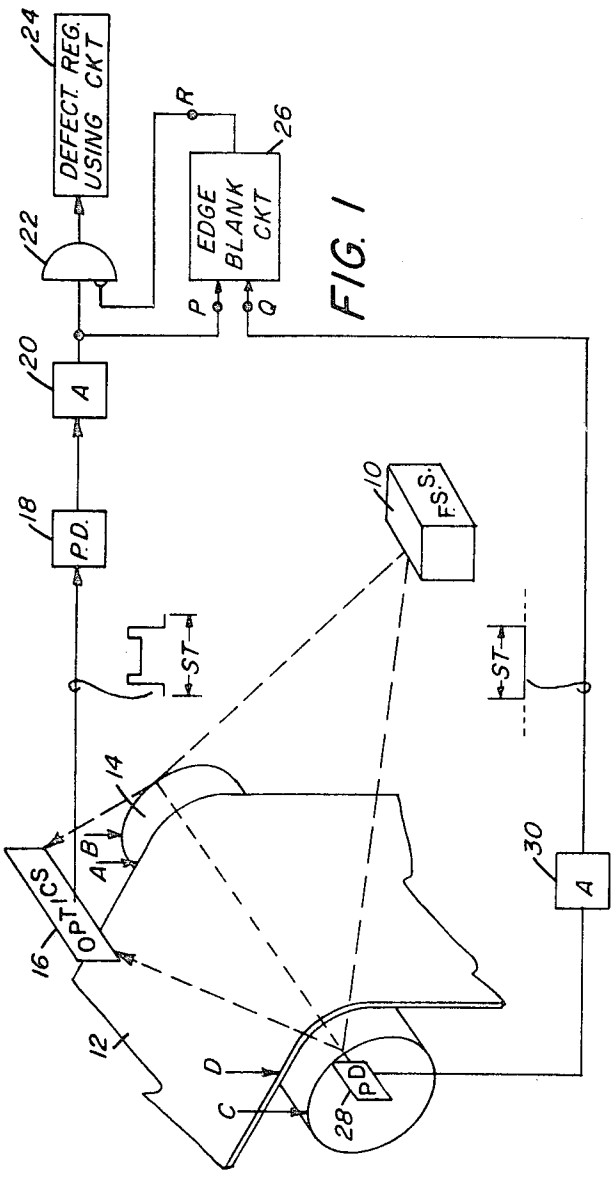


FIG. 1

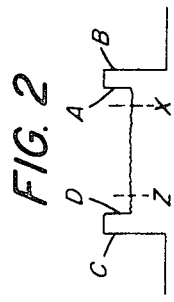


FIG. 2

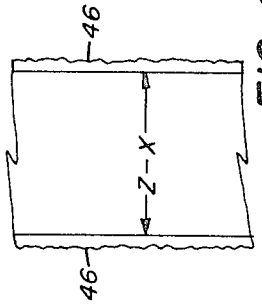


FIG. 4

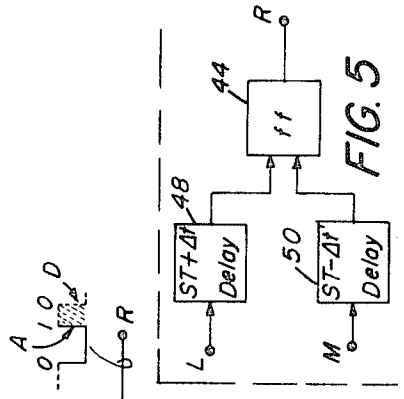


FIG. 5

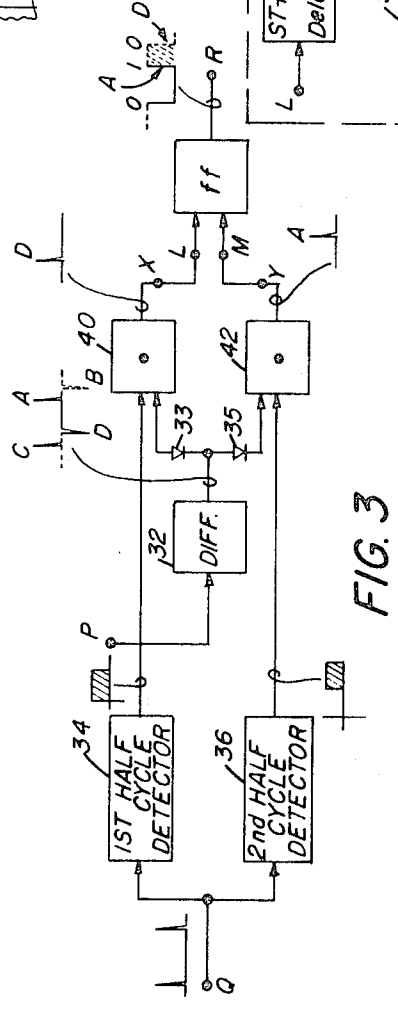


FIG. 3

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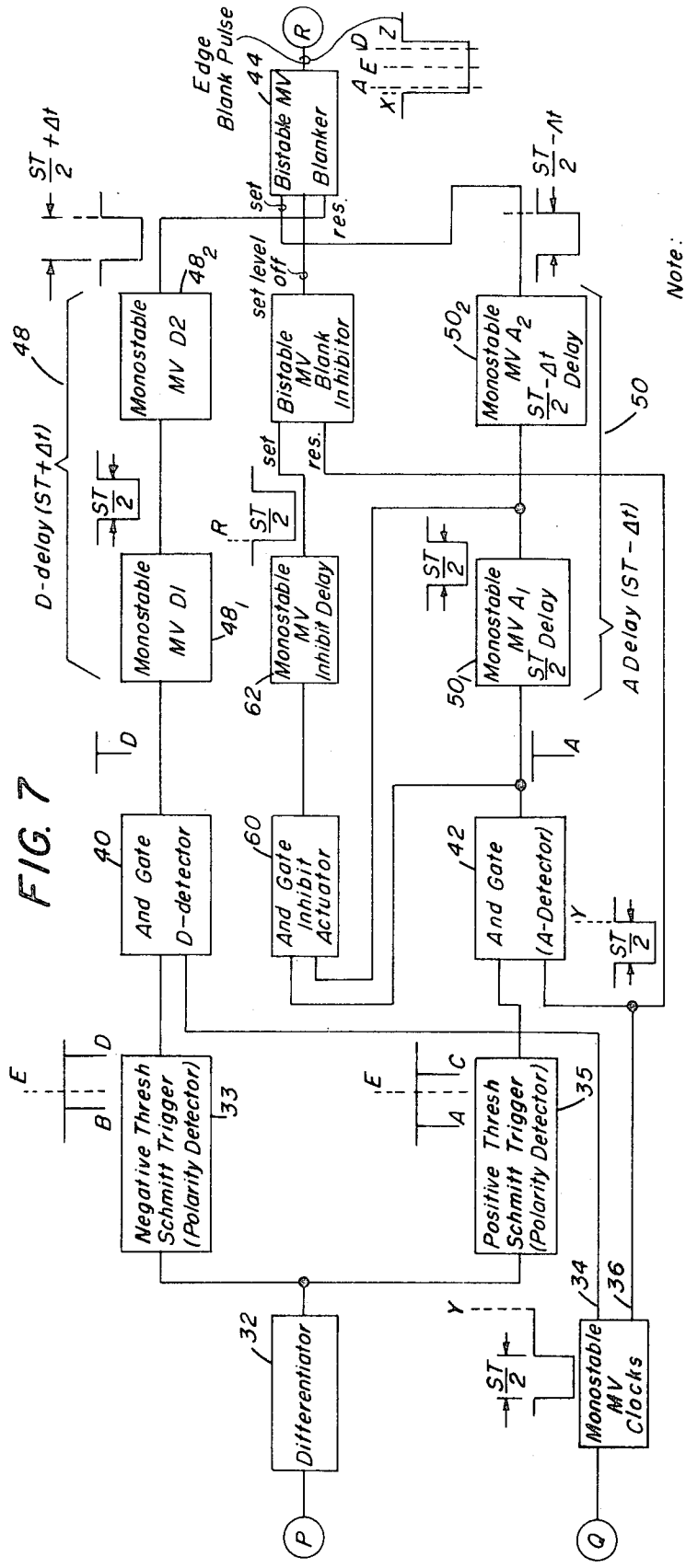


FIG. 7

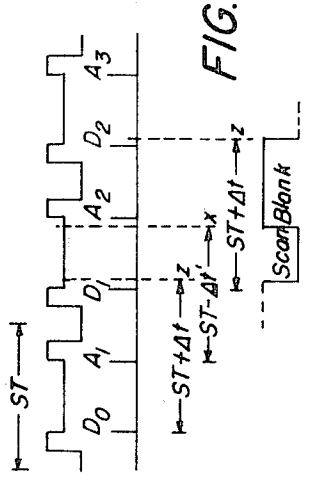


FIG. 6

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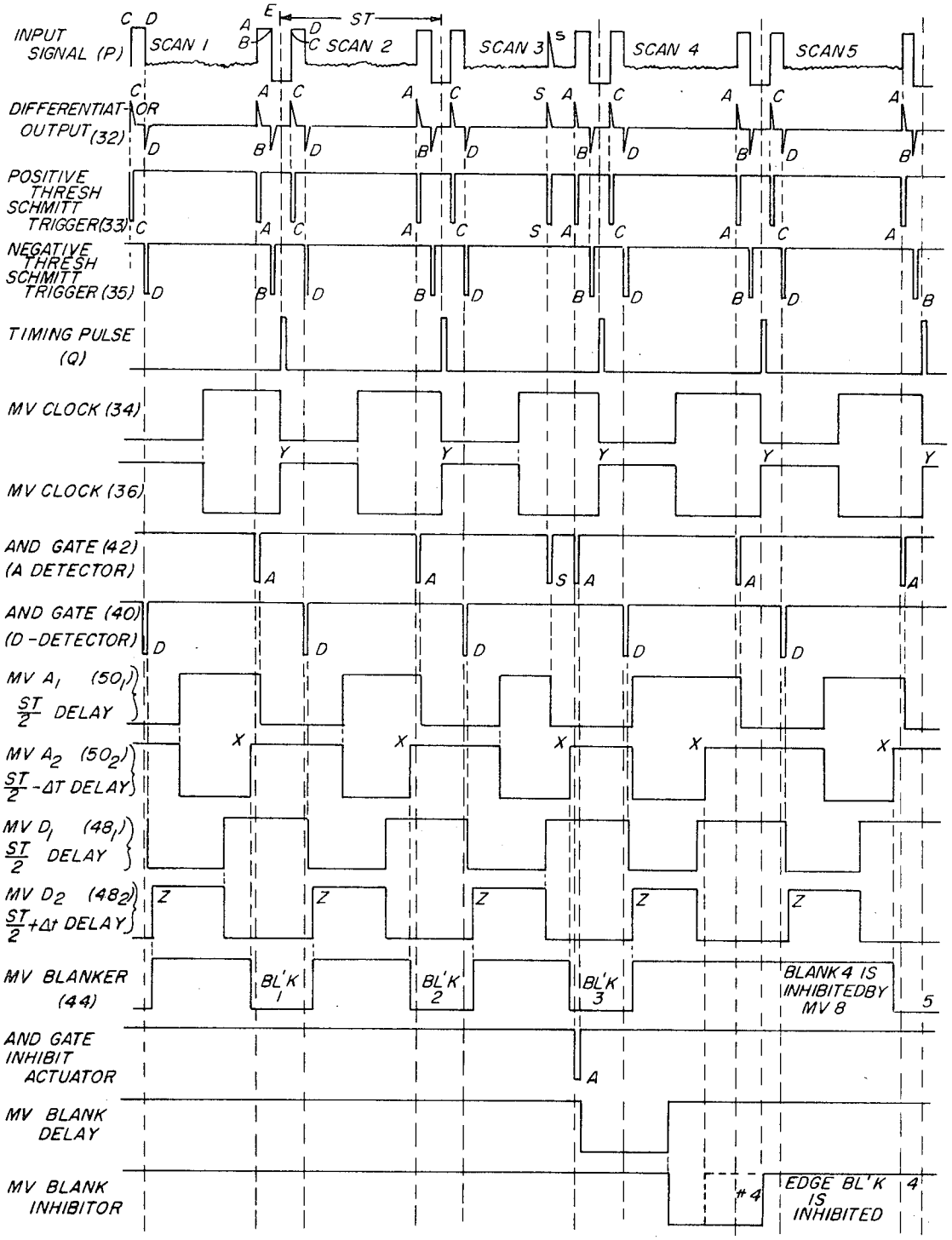


FIG. 8

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FLYING SPOT SCANNER BLANKING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to flying spot scanners, and in particular to such scanners as are useful for inspecting webs and the like.

2. Description Relative to the Prior Art

Consider a web which, while being subject to the spot of a flying spot scanner, passes over a wide web-supporting surface. Modulation of the spot occurs as the spot (1) first passes onto the web-supporting surface, (2) passes from such surface onto the edge of the web, (3) passes over defects in the web, (4) passes from the edge of the web back onto the web-supporting surface, and (5) moves off the web-supporting surface. Generally, only spot modulation caused by web defects is useful for determining web quality; and thus, it is the prior art practice to blank, by one means or another, spot modulation which is not defect-dependent.

It frequently obtains that web defects are created, near the edges of a web, as a result of slitting, and otherwise handling, the web; and thus, blanking must also cancel edge-defect modulation to prevent inadvertent registration of defects which have no material bearing on the quality of the web.

U.S. Pat. No. 3,198,951, indicates a blanking method which is dependent on placing photopickups proximate the edges of a web, respectively to turn-on and turnoff a defect detection circuit.

U.S. Pat. Nos. 3,360,651 and 3,510,664, both, apparently, recognize that the system of U.S. Pat. No. 3,198,951 (1) cannot tolerate weaving of a web over a supporting surface, (2) requires repositioning of photopickups to accommodate different size webs, and (3) cannot be effective, without modification, for inspecting webs of nonuniform width. U.S. Pat. Nos. 3,360,651, and 3,510,664, suggest that spot modulation, as caused by web edges, be used for blanking purposes: the former producing a "gate-on" pedestal pulse in response to the lead edge of a web; and the latter employing a counting technique for gating on and off, and registering defects.

U.S. Pat. No. 3,360,651, is considered closest, in concept, to the present invention: U.S. Pat. No. 3,360,651, teaches that spot modulation corresponding to the edges of the web may be used to define a pedestal pulse for gating a defect detector into and out of operation. In addition, U.S. Pat. No. 3,360,651, teaches the effective narrowing of such pedestal pulse to prevent defect detection at the edges of the web under inspection. Pedestal narrowing is accomplished in U.S. Pat. No. 3,370,651, by pulse delay techniques involving feedback controls; and whereby the system of U.S. Pat. No. 3,360,651, automatically corrects for webs of varying widths.

So long as the surface over which the web of U.S. Pat. No. 3,360,651, passes is unproductive of signals as the flying spot of the scanner in question moves onto and off such surface, the system of U.S. Pat. No. 3,360,651 will undoubtedly be effective for its intended purpose. Consider, however, the production of scan signals having the above-mentioned five occurrences of modulation during a given scan. Needless to say, were signals of such type to be applied to the Schmitt trigger circuit of U.S. Pat. No. 3,360,651, such circuit would undesirably operate two extra times during each scan of the flying spot, thereby preventing the proper operation of its pedestal defining circuit. Such extra triggering occurs because scan signals, of the type to be handled by apparatus according to the invention, produces "two" positive and "two" negative spike pulses for each flying spot scan, whereas scan signals which are handled by the apparatus of U.S. Pat. No. 3,360,651, produce only two spike pulses for each flying spot scan.

SUMMARY OF THE INVENTION

The invention principally concerns a way to distinguish between pulses which define the edges of a web, as opposed to pulses which define the edges of a web-supporting surface.

Distinguishing between such pulses, according to the invention, is predicated on the use of clock pulses: A first clock pulse corresponding to a first portion (half) of the scan signal gates signals of one sense to an edge blank circuit (or pedestal producing circuit); and a second clock pulse corresponding to a second portion (half) of the scan signal gates signals of the opposite sense to the edge blank circuit (or pedestal producing circuit). In one version of the invention, each scan signal has, during each of its halves, first and second pairs of steep positive- and negative-going signal changes. By using a first clock to gate the positive-going signal change of the first scan signal half, and by using a second clock to gate the negative-going signal change of the second scan signal half, the inner and outer bounds of the web may be defined. In other words, the present invention proposes to split the scan signal into halves, by means of the aforesaid clock pulse technique, thereby to distinguish the pulses which define the bounds of the web-supporting surface, and of the web itself.

Two other aspects of the invention obtain: (1) a technique for producing a pulse that appears to occur in response to, but before another pulse, and (2) a technique for distinguishing between large defect signals during a flying spot scan, and signals which result from spot modulation caused by the web-supporting surface.

OBJECTS OF THE INVENTION

1. To provide blanking in a flying spot scanner system employed to inspect webs that are supported on a signal-producing surface;

2. To simulate the generation of a pulse a predetermined time before the occurrence of a signal which appears to trigger such pulse, etc.

The invention will be described with reference to the figures, wherein:

FIG. **1** illustrates in block form a web inspection system adapted to accommodate the invention,

FIG. **2** illustrates a signal form of a type which may be processed by means of the invention,

FIG. **3** is a schematic block diagram of a circuit according to the invention,

FIG. **4** is a plan view of a web illustrating scan dimensions according to the invention in a presently preferred form thereof,

FIG. **5** is a block diagram of a circuit which may be connected into the circuit of FIG. **3** to provide the scan dimensions indicated in FIG. **4**,

FIG. **6** illustrates pulse diagrams useful for describing the combined apparatuses of FIGS. **1**, **3**, and **5**,

FIG. **7** is an overall block diagram of apparatus embodying the various features of the invention, and

FIG. **8** illustrates pulse diagrams useful for understanding the operation of the circuit of FIG. **7**.

Referring to FIG. **1**, a flying spot scanner **10** causes a beam of radiation to sweep across a web **12** which rides over a web-supporting roller **14**. The roller **14** has a reflectivity different from that of the web **12**; and light reflected from the web **12** and roller **14** is collected by optics **16** and directed to a photodetector **18**. Each flying spot scan produces an optical signal like that shown in FIG. **2**.

FIG. **2** indicates that the optical signal applied to the photodetector **18** increases (C) as the flying spot first goes onto the (shiny) surface of the roller **14**, drops (D) as the spot goes onto the web **12**, varies in response to web defects, increases (A) when the spot goes back onto the (shiny) roller, and drops (B) to an ambient level when the spot goes off such roller.

Output signals from the photodetector **18** are amplified (**20**) and applied to a gate circuit **22** which, in turn, applies such signals to a device **24** for registering the occurrence of defect representative signals. Operation of the gate circuit **22** depends on the occurrence of an edge blank pulse from a circuit **26**, which pulse inhibits the operation of the gate circuit

22. The edge blank circuit 26 receives the amplifier 20 output signals, and signals from a photodetector 28 (and amplifier 30) that defines the point at which the flying spot first starts to sweep across the roller-and-web, thereby to produce the edge blank pulses. The photodetector 28 output signals have a scan duration (ST) as indicated.

The edge blank circuit 26 of FIG. 1 is indicated in detail in FIG. 3; note contacts P,Q,R:

A differentiator circuit 32 is adapted to receive the flying spot scan signal (FIG. 2); and produces therefrom a pair of spike pulses corresponding to the signal changes C,D and A,B. Since the signal duration which occurs between D and A corresponds to the period of scanning which is of interest, the invention proposes to isolate the signal occurrences D and A, each by means of a respective clock pulse. Such isolation is necessary because of the signal producing characteristics of the web-supporting roller 14 . . . which is to say that positive- and negative-going spike pulses are produced during both the first and second halves of each scan (ST). The negative-going signal (D) that defines the lead edge of the web is isolated from the negative-going signal (B) that defines the trailing edge of the web-supporting roller 14 by means of a polarity detector 33 and a clock from a first half-cycle detector 34; and the positive-going signal that defines the trailing edge (A) of the web 12 is isolated from the positive-going signal (C) that defines the lead edge of the web-supporting roller 14 by means of a polarity detector 35 and a clock from a second half-cycle detector 36. The half-cycle detectors 34,36 may take the form of counter leads on a monostable multivibrator that is responsive to the output of the roller-edge defining photodetector 28; such a multivibrator having a cycle of operation corresponding to the duration ST/2.

A pair of AND-gates 40,42 respectively receive the negative- and positive-going spike pulses, and the first and second half cycle clocks; and attendantly, such AND-gates 40,42 respectively produce the web-scan defining pulses D and A which turn a flip-flop 44 off and on, thereby respectively to uninhibit and inhibit the operation of the gate 22. The crosshatched area of the signal output of the flip-flop 44 represents an edge blank pulse so produced.

As stated above, it frequently obtains that a web is to be inspected across less than its full width (see dimensions Z-X, FIG. 4), thereby to prevent the ragged edges 46 of the web from producing defect signals. This means the blank pulse must be widened; which at first blush suggests that the edges A and D of the flip-flop 44 output are to be respectively advanced and delayed. However, since the occurrence of such edges are unpredictable, i.e., they depend on the nature of the scan signal, the matter of "edge advancing," as opposed to edge delaying, is an impossibility. To simulate edge-advancing, the invention proposes a signal delay technique: the signal (A) to be advanced being delayed for a little less than the duration ST; and the signal (D) to be delayed being delayed a little longer than the duration ST. Thus, in accordance with the invention, signals which are produced during one scan are employed for generating a widened blanking pulse for use during a subsequent scan. FIG. 5 shows a circuit adapted to be connected to contacts L,M,R of FIG. 3 to implement the widening of an edge blank pulse, i.e., the circuit of FIG. 5 indicates appropriate delay devices 48,50 cooperative with the flip-flop 44.

Reference should now be had to FIG. 6 which graphically illustrates how blank-defining pulses A_1 and D, effect a blanking pulse that overlaps (by Δt and $\Delta t'$) blank-defining pulses A_2 and D_2; which is to say that blanking, for a given flying spot scan, is determined during an earlier scan . . . and such blanking will be effective for ordinary rates of web travel.

The following description, relating to apparatus of FIG. 7, indicates a working arrangement for the circuit techniques discussed above in connection with FIGS. 3 and 5: Similar characteristic notations are employed in all such figures for corresponding components. See also the waveforms of FIG. 8:

A monostable multivibrator, responsive to the output of the photodetector 28, produces a pair of complementary clock pulses (34,36), each having a duration ST/2. For polarity detectors 33,35, Schmitt triggers respectively responsive to predetermined negative and positive signal level outputs from the differentiator 32 are employed; and their respective outputs are applied to the AND-gates 40,42 together with respective clocks 34,36, thereby to isolate the signals D and A.

To delay the signal D, as required, a pair of multivibrators 48_1 and 48_1 are employed. The multivibrator 48_1 produces a pulse of duration ST/2; and the multivibrator 48_2, responsive to the trailing edge of the pulse from the multivibrator 48_1, produces a pulse of duration ST/2+Δt.

Similarly, the signal A is delayed by a pair of multivibrators 50_1 and 50_2, the former for a duration ST/2, and the latter for a duration of ST/2−Δt.

By means of the D and A delays 48,50, the flip-flop 44 (bistable multivibrator) is respectively reset and set—in response to a given pair of D and A signals—a little more, and a little less, than a scan duration after such D and A signals are produced, thereby causing the multivibrator 44 to appear to reset in response to, and after, a signal which has just occurred, and to set in response to, and before, a signal which has not yet occurred.

The bistable multivibrator 44 serves to inhibit the gate 22 in the manner described above.

For certain web defects, such, for example, as a break or hole in the web being inspected, steep large amplitude signals S, sufficient to trigger the (positive) Schmitt trigger 33, are applied to the differentiator 32. See scan 3, FIG. 8. When a signal S occurs during the second half of a flying spot scan, it is gated through the AND-gate 42 and will, absent the improvement to be described presently, effectively widen the blanking pulse so that the defect S will go undetected. (The second half of a flying spot scan, as opposed to the first half, is of concern for the reason that only during the second scan half are positive thresholds of interest.) To avoid so widening the blanking pulse, in response to a large defect signal, that such signal may go undetected, the invention proposes to change circuit timing in response to large defect signals S, so that the signal A will turn off the flip-flop 44 (i.e., so inhibit its operation that it remains in its reset state), thereby to cause defect registration (24) to be in response to signal outputs produced from the web-supporting roller 14.

To this end, an AND-gate 60 is adapted to receive the signal A and the delayed half cycle pulse of the multivibrator 50_1 and, since such signals are usually of opposite polarity, the AND-gate 60 usually has no output. As soon, however, as the multivibrator 50_1 has the timing of its output pulse shifted by a signal S, the signal A gets gated out of the AND-circuit 60. A multivibrator 62, the purpose of which is to complement the half-cycle delay of the multivibrator 50_1 so that the effect of the isolated signal A will be a full scan duration after its occurrence, sets a bistable multivibrator 64 so that such multivibrator may inhibit the operation of the blank pulse producing multivibrator 44. Thus, the occurrence of a large defect signal S during the second half of a scan duration effectively turns off the multivibrator blanker 44, the gate circuit 22 being thereby left open so that signals from the web-supporting roller may be registered.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. For example, whereas half-cycle clocks are indicated, such clocks may be longer or shorter durationwise than a half-cycle, so long as they complement occurrencewise the pulses which they are intended to isolate; the durations Δt and $\Delta t'$ may be alike or different; the delays afforded by the components 48,50 may be respectively a little more and a little less than multiples of the duration ST, etc.

What is claimed is:

1. A system for inspecting webs which are conveyed over a web-supporting surface, said surface and said web having substantially different abilities to modulate incident radiation, comprising:

a. a flying spot scanner for beaming and sweeping, at a given cyclic rate, a source of radiation across said surface and said web,

b. means for collecting radiation from said surface and said web for producing signals corresponding to respective radiation sweeps,

c. gate circuit means adapted to receive signals produced by said radiation collecting means, and

d. means for producing gating signals for controlling the operation of said gate circuit means, said means for producing gating signals comprising:

1. means for producing first and second sets of clock signals, the signals of said first set corresponding durationwise with the first half of each said radiation sweep, and the signals of said second set corresponding durationwise with the second half of each said radiation sweep,

2. means for receiving and differentiating said signals produced by said radiation collecting means for producing pairs of edge-defining spike pulses during the first and second halves of each radiation sweep, said spike pulses corresponding to radiation modulation as said radiation sweeps onto and off said web-supporting surface,

3. first and second AND gate means for receiving respectively said first and second sets of clock signals,

4. means for applying the spike pulses, corresponding to radiation modulation as said radiation sweeps from said surface onto said web, to said first AND gate means,

5. means for applying the spike pulses, corresponding to radiation modulation as said radiation sweeps from said web onto said surface, to said second AND gate means, and

6. bistable means cooperative with said gate circuit means, and responsive to the pulse outputs of both said AND gate means, thereby to place said gate circuit means in a signal passing state while said radiation sweeps across said web.

2. The apparatus of claim 1 including: AND gate

a. first means for delaying the application to said bistable means of the output of said first AND gate means by a duration slightly longer than a given multiple of the time that it takes to sweep radiation across said surface and said web, and

b. second means for delaying the application to said bistable means of the output of said second AND gate means by a duration slightly less than said given time multiple.

3. The apparatus of claim 2:

a. wherein said first delay means comprises first and second monostable multivibrators for producing respective square wave signals, said first multivibrator being responsive to the output of said first AND gate means and said second multivibrator being responsive to the trailing edge of the signal output of said first multivibrator, the combined durations of said square wave signals being slightly greater than the said sweep time of said flying spot scanner, and

b. wherein said second delay means comprises third and fourth monostable multivibrators for producing respective square wave signals, said third multivibrator being responsive to the output of said second AND gate means and said fourth multivibrator being responsive to the trailing edge of the signal output of said third multivibrator, the combined durations of said square wave signals from said third and fourth multivibrators being slightly less than the said sweep time of said flying spot scanner.

4. The apparatus of claim 1 including:

a. circuit means for distinguishing between said edge defining spike pulses and spike pulses produced in response to large web defects, and

b. means responsive to defect-produced spike pulses for placing said gate circuit means in its signal passing state.

5. The apparatus of claim 1 wherein:

a. said web has a photographically sensitized surface,

b. said web-supporting surface is a roller drum, the axial dimension of which is wider than said web, and

c. said roller drum, at least proximate its extremities, has a mirrorlike surface.

6. The apparatus of claim 5 including:

a. circuit means for distinguishing between said edge-defining spike pulses and spike pulses produced in response to large web defects, and

b. means responsive to defect-produced spike pulses for placing said gate circuit means in its signal passing state.

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