United States Patent [19]

Nichols et al.

[11] **3,898,469**

[45] **Aug. 5, 1975**

[54] **DATA ROUTER FOR A FLAW DETECTION SYSTEM**

[75] Inventors: **Peter H. Nichols**, Cheshire; **Monty M. Merlen**, Stamford, both of Conn.

[73] Assignee: **Intec Corporation**, Norwalk, Conn.

[22] Filed: **May 31, 1974**

[21] Appl. No.: **475,189**

[52] **U.S. Cl.** ..... **250/563**; 356/200; 235/92 V

[51] **Int. Cl.** **G01n 21/32**

[58] **Field of Search** ..... 250/562, 563, 571, 572, 250/559; 356/199, 200; 235/151.3, 61.11 E, 92 V; 356/237, 238

[56] **References Cited**

UNITED STATES PATENTS

3,445,672	5/1969	Marks	356/237
3,541,340	11/1970	Binks	250/562
3,560,096	2/1971	Watson et al.	250/563 X
3,729,619	4/1973	Laycak et al.	235/92 V X
3,781,117	12/1973	Laycak et al.	250/563 X
3,781,531	12/1973	Baker	235/151.3

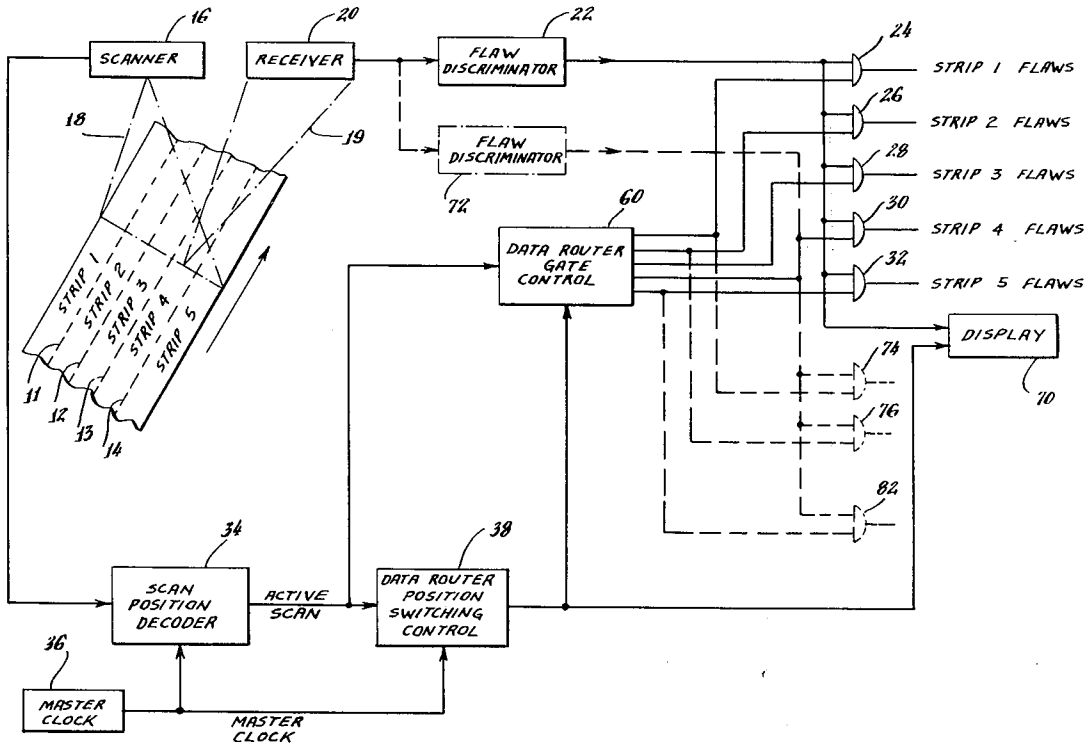
Primary Examiner—Walter Stolwein

Attorney, Agent, or Firm—Joseph Levinson, Esq.

[57] **ABSTRACT**

A light source in the form of a laser beam is scanned successively across the surface of a web of moving material and the intensity of the beam, either reflected, transmitted, or scattered, is detected by a receiver which provides an indication of flaws which occur on the surface. For many applications the web of material is later divided into strips or segments for ultimate use, or it is otherwise desirable to determine on what segments of the web the flaws occur. In accordance with the present invention, an electronic data router is provided which is manually set by switches to locate the demarcation lines between segments of the material to divide the material into discrete strips for flaw indication purposes. Scan position information is fed to preset counters set by the aforesaid switches which provide outputs at the desired demarcation lines to divide the material as desired. Flaws passed by discriminators are fed to gates which are enabled by the data router for predetermined intervals corresponding to predetermined lines forming the strips on the material. By using a plurality of discriminators and gates with the same scanner, receiver and data router, a variety of different types of flaws may be sorted in accordance with their occurrence on predetermined segments of the web of material being examined.

8 Claims, 2 Drawing Figures



STRIP 1 FLAWS
STRIP 2 FLAWS
STRIP 3 FLAWS
STRIP 4 FLAWS
STRIP 5 FLAWS
DISPLAY
70
24
26
28
30
32
74
76
82
60
DATA ROUTER GATE CONTROL
22
FLAW DISCRIMINATOR
72
FLAW DISCRIMINATOR
38
DATA ROUTER POSITION SWITCHING CONTROL
20
RECEIVER
19
ACTIVE SCAN
MASTER CLOCK
16
SCANNER
STRIP 5
STRIP 4
STRIP 3
STRIP 2
STRIP 1
18
11
12
13
14
34
SCAN POSITION DECODER
36
MASTER CLOCK

Fig. 1.

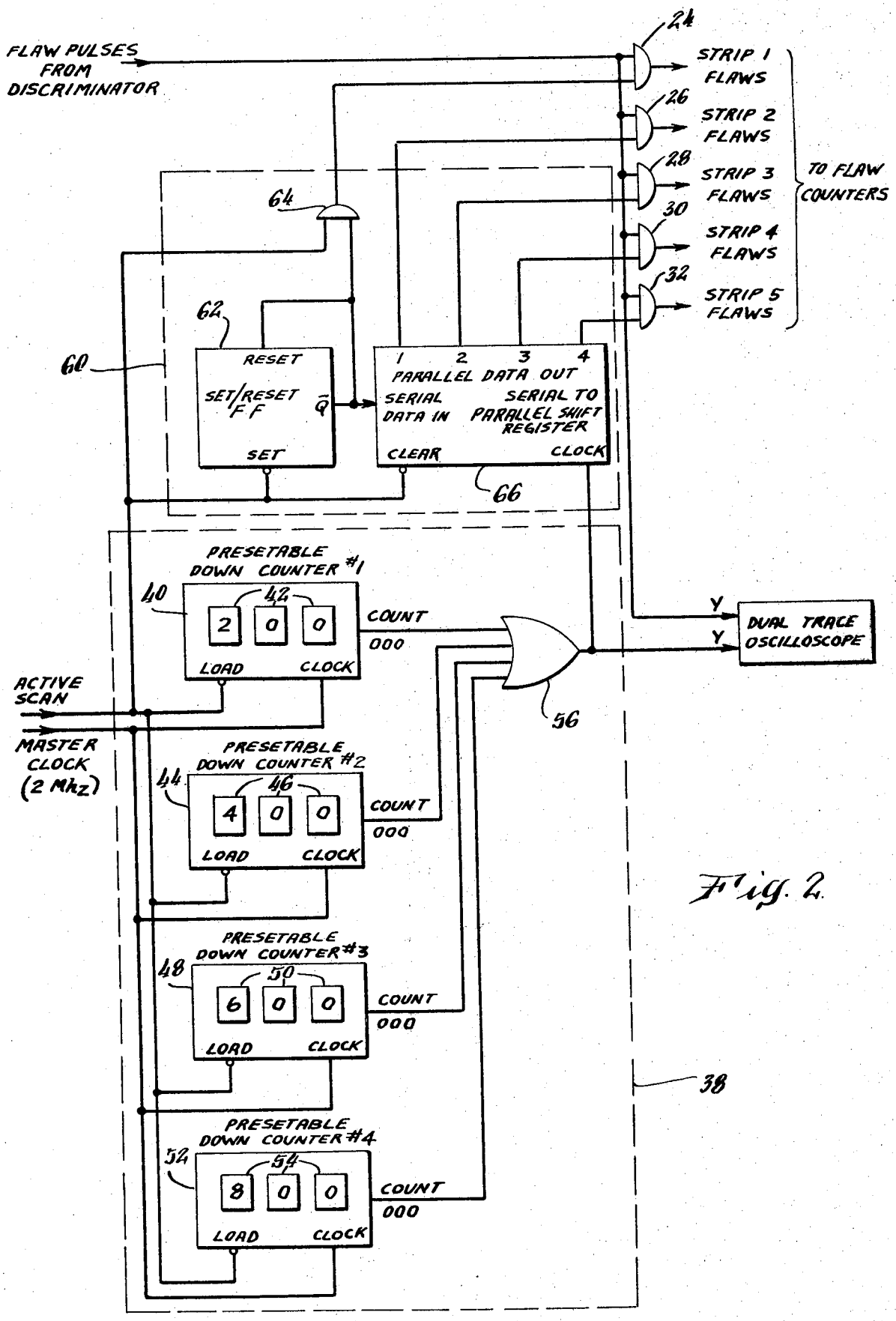

FLAW PULSES FROM DISCRIMINATOR
24
STRIP 1 FLAWS
26
STRIP 2 FLAWS
28
STRIP 3 FLAWS
30
STRIP 4 FLAWS
32
STRIP 5 FLAWS
TO FLAW COUNTERS
64
62
60
RESET
SET/RESET FF
SET
1 2 3 4
PARALLEL DATA OUT
SERIAL DATA IN
SERIAL TO PARALLEL SHIFT REGISTER
CLEAR
CLOCK
66
PRESETABLE DOWN COUNTER #1
40
42
2 0 0
LOAD
CLOCK
COUNT
000
Y
Y
DUAL TRACE OSCILLOSCOPE
56
ACTIVE SCAN
MASTER CLOCK (2 Mhz)
PRESETABLE DOWN COUNTER #2
44
46
4 0 0
LOAD
CLOCK
COUNT
000
PRESETABLE DOWN COUNTER #3
48
50
6 0 0
LOAD
CLOCK
COUNT
000
38
PRESETABLE DOWN COUNTER #4
52
54
8 0 0
LOAD
CLOCK
COUNT
000

Fig. 2.

DATA ROUTER FOR A FLAW DETECTION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a laser scanner flaw detection system for the detection of flaws on a moving web of material, and more particularly to such a system utilizing a data router for dividing the web of material electrically into segments or strips for providing an indication of which strips contain flaws.

The present invention has application to the laser scanner flaw detection systems of the type shown and described in U.S. Pat. No. 3,781,531 issued Dec. 25, 1973, patent application Ser. No. 449,247 filed Mar. 8, 1974, and patent application Ser. No. 465,510 filed Apr. 30, 1974, all of which are assigned to the assignee of the present invention. In the aforesaid systems flaws are detected in the surfaces of the material being examined by repetitively scanning a suitable light source, such as a laser beam, across the surface of the material. The laser light is reflected, transmitted, or scattered from the material, depending upon the characteristics of the material, which light is picked up by a receiver including a suitable detector, such as a photomultiplier tube. At any instant of time during the scan, the photomultiplier output varies with the reflectivity, transmissivity or scattering properties of the spot upon which the laser beam is impinging, and deviations from normal variations provide a means for indicating material flaws. For a number of applications, the web of material being examined is ultimately cut into strips or segments for use. For example, the web of material may be plastic, paper, magnetic tape, etc., which is manufactured in a wider web than will ultimately be used, but is done so for uniformity and the savings in manufacturing cost in not having to manufacture narrower strips. It would be useful, then, to have flaw data related to the strips into which the web is divided for proper monitoring of the material as well as the manufacturing process. Furthermore, if flaw data is available for specific areas or segments of the web, only the faulty strips or portions need be discarded, saving areas of the material which are unflawed and which may still be useful. Furthermore, in the manufacturing process, if a flaw continues to exist along a certain strip, the manufacturing process itself may be examined pertaining to the area of the flaw to locate wherein the process is faulty. Of course, the examination of different segments or strips of the web of material could be accomplished by providing a multiplicity of laser scanning systems which would only scan predetermined portions of the web of moving material. This approach would be unwieldy and extremely expensive to implement. The provision for providing different types of data from the same area would also amount to a large duplication of components using the multiple system approach.

Accordingly, it is an object of the present invention to provide a new and novel laser scanner flaw detection system for sorting data information in accordance with its position on the material being examined.

A further object of this invention is to provide a new and improved laser scanner flaw detection system for providing a plurality of flaw data information without employing a plurality of laser scanners.

Still another object of this invention is to provide a new and improved laser scanner flaw detection system in which the material being examined may automatically be divided into discrete segments or strips for data presentation, and where a variety of types of data may be obtained utilizing the same basic system without complete duplication of parts.

Another object of this invention is to provide a new and improved laser scanner detection system which may easily be preset to divide the material being examined into strips or segments, and data produced shall relate to flaws occurring individually on each of those strips or segments.

SUMMARY OF THE INVENTION

In carrying out this invention in one illustrative embodiment thereof, a scanner is provided for successively scanning a laser beam across the surface of material being examined, and a receiver is positioned for receiving and detecting radiation from the material for producing a signal in response to the radiation received. The signal output of the receiver is applied to a flaw discriminator and from there to a plurality of flaw gates. Scan position information from the scanner is applied to a data router which includes a data router position switching control means having a plurality of settable switches and counters for presetting lines on the material being examined which in effect divide the material into preset discrete strips. Output from the data router position switching control is applied to a data router gate control means whose output is applied to the flaw gates. The flaw gates are thus controlled to pass flaw data on predetermined strips of the material being examined in accordance with the switching positions of the data router position switching control means. By using a plurality of flaw discriminators and flaw gates, a variety of data may be provided in accordance with the type of flaw, for example amplitude, polarity, width, height, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the data router for a flaw detection system embodied in this invention.

FIG. 2 is a schematic diagram illustrating one form of data router position switching control and data router gate control means which may be utilized in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, a scanner 16 is provided which scans a suitable light source, such as a laser beam 18, successively across a web of material 10 which is continuously moving in the direction shown on the drawing. The scanner 16 causes the beam 18 to scan back and forth across the surface of the material 10, and scanning in the orthogonal direction to create a raster is accomplished automatically by the movement of the web of material 10. Light 19 reflected from the material 10 is applied to a receiver 20 having a detector 21 therein of a suitable type, such as a photomultiplier tube which detects the light applied thereto. At any instant of time during the scan the detector 21 provides an output which is proportional to the reflectivity of the spot on which the light beam 18 is impinging. Flaws occurring on the surface of the material 10 being examined change the output of the detector 21 due to the reflective properties of the material being examined, providing a means for indicating flaws on the surface of the material 10. Although different types of scanners and receivers may be utilized, one form of scanner 16 and

receiver **20** which are suitable for the present application are shown and described in an application entitled "Laser Scanner Flaw Detection System," Ser. No. 449,247, referred to above. Although a reflective type system is illustrated for purposes of disclosure, a transmissive type system where the output of the detector **21** is proportional to the tramsmissivity of the spot on which the laser beam is impinging is also applicable to the present invention. Whether a transmissive or a reflective mode is utilized will depend upon the application and the type of material being examined.

Signals from a detector of the receiver **20** are applied to a flaw discriminator **22** which will pass flaw signals of a predetermined amplitude. A plurality of flaw discriminators may be provided, one being indicated in dotted lines as flaw discriminator **72**, which may be designed to pass flaws having different characteristics, for example different polarities, widths, lengths, etc. Flaw signals which pass the flaw discriminator **22** are applied to flaw gates **24, 26, 28, 30,** and **32,** whose function will be described hereinafter.

Returning to the web **10,** it will be noted that the web is arbitrarily divided into five strips by demarcation lines **11, 12, 13,** and **14.** The strips and demarcation lines have been arbitrarily selected for purposes of illustration to indicate that it is desirable to break the web up into strips or segments. The purpose of the present invention is to provide a means of providing separate data channels for each strip which indicate the flaws occurring on each strip. In order to do so, scan position information is fed from the scanner **16** to a scan position decoder **34** which is also fed by a master clock **36.** The function of the scan position decoder is to define and generate signals representative of the active scan interval. The type of scan position decoder which is utilized may take many forms depending on the type of scan which is used, whether linear or sinusoidal, or whether edge-to-edge scan is used or center-to-side scan is used. The important function of the scan position decoder **34** is to provide and define the active scan interval. The master clock **36** and scan position decoder **34** form the synchronization system for the circuitry, and may utilize the type shown in the aforesaid patent and patent applications. Active scan position information is fed from the scan position decoder **34** to a data router position switching control **38** which also has the master clock **36** coupled thereto. The active scan is also fed to a data router gate control circuit **60** along with the output of the data router position switching control **38.** Output pulses from the data router position switching control **38** correspond in time to scanning across the demarcation lines **11, 12, 13** and **14** of strips **1, 2, 3, 4** and **5** illustrated on the web of material **10.** The separate outputs of the data router gate control circuit **60** are coupled to the flaw gates **24, 26,** 28, 30 and **32** for enabling those gates to pass flaw signals which occur while the beam is scanning each defined strip.

Referring now to FIG. **2** for a more detailed description of the circuits **38** and **60,** the data router position switching control **38** in the illustrated form comprises a plurality of presettable down counters **40, 44, 48** and **52.** The counters **40, 44, 48** and **52** are provided with a plurality of thumb wheel switches **42, 46, 50** and **54,** respectively. The aforesaid counters are set by their respective thumb wheel switches to produce an output which corresponds to the lines **11, 12, 13** and **14** on the web of material **10** illustrated in FIG. **1** to effectively divide the web of material into strips or segments. Each of the counters has coupled thereto active scan position information from the scan position decoder **34** and clock pulses from the master clock **36.** During inactive scan intervals, which correspond to the time intervals during which scan retrace occurs, the thumbwheel switch settings are loaded into each of the counters. When each active scan interval starts, the counters begin counting down. When each counter reaches count **000** an output pulse occurs which is applied to OR gate **56.** As is illustrated in FIG. **2,** counter **40** is set at **200.** and when **200** clock pulses occur after the start of active scan, an output pulse is applied to OR gate **56.** Similarly, counters **44, 48** and **52** produce output pulses when the number of clock pulses received by them after the start of an active scan interval correspond to their thumb wheel switch settings. In time, the output of counter **40** corresponds to line **11** position, the output of counter **44** corresponds to line **12** position, the output of counter **48** corresponds to line **13** position, and the output of counter **52** corresponds to line **14** position being scanned on the web of material **10.** OR gate **56** combines and couples the individual counter outputs to the data router gate control **60** and to oscilloscope display **70.**

The data router gate control **60** includes a $\overline{\text{set}}$-reset flipflop **62,** a gate **64,** and a serial-to-parallel shift register **66.** Active scan position information is fed to the AND gate **64,** the $\overline{\text{set}}$ terminal of the flipflop **62,** and the $\overline{\text{clear}}$ terminal of the shift register **66.** Accordingly, during inactive scan intervals the shift register **66** is cleared and the Q output of flipflop **62** is set to logic 1. The output of AND gate **64** which is coupled to flaw gate **24** goes to logic 1 when the active scan line goes to logic 1, enabling flaw gate **24** to pass flaws during the scanning of strip **1** on the web of material **10.** Flaw gate **24** remains enabled until the counter **40** produces an output at OR gate **56** which is connected to the clock terminal of shift register **66.** This transfers the logic 1 level from the Q output of flipflop **62,** which is connected to the serial data input terminal of the shift register **66,** to its first parallel output terminal. Terminal **1** is connected to the reset input of flipflop **62,** and the occurrence of logic 1 causes the flipflop **62** output to go to logic 0. This causes the output of AND gate **64** to go to logic 0, which disables flaw gate **24.** Output terminal **1** of the shift register **66** is also coupled to the flaw gate **26,** thereby enabling flaw gate **26** when flaw gate **24** is disabled. Accordingly, the output from flaw gate **24** which corresponds to flaws occurring on strip **1** is now disabled, and the system has moved to strip **2** on the web of material **10** corresponding to the flaw gate **26.** As the counters continue to count during the active scan, as each of the counters reaches the down count of **000,** the logic 1 level at output **1** of shift register **66** transfers successively to outputs **2, 3,** and **4,** enabling a new flaw gate and disabling the previous one. When the active scan is completed, the clear terminal of shift register **66** is actuated, causing output **4** to go to logic 0, thereby disabling strip **5** flaw gate **32.** This cycle repeats on successive scans, which effectively provides a means for routing data corresponding to five different segments of the web of material **10.**

The outputs from the OR gate **56** are also applied to a display **70,** which may be a dual trace oscilloscope with the Y inputs consisting of the output of the OR

gate **56** and the flaw pulses from the discriminator **22.** One convenient way of setting the lines **11, 12, 13** and **14** would be to place wires on the web of material during setup, corresponding to the lines which are desired to break up the web into segments. These lines when scanned by the scanner produce a trace on the oscilloscope, indicating the demarcation points and the counters can be set to provide output pulses in accordance with the position of the wires which will show up as flaws on the surface of the material. Accordingly, a very simple setting means is provided for dividing the web into the desired strips. The strips, for example, may correspond to cutter blades which are positioned later in the manufacturing process, with the wires merely being aligned with the cutter blades to divide the strip in accordance with its end use.

As explained previously, a plurality of different discriminators may be utilized to segregate and provide more information with respect to the type of flaw which is encountered on each of the strips. As is illustrated in FIG. **1,** a flaw discriminator **72,** which, for example, could pass flaws of different polarity than that of flaw discriminator **22,** or could provide a flaw of a discrete width, height, etc., has its output applied to another series of flaw gates **74, 76 . . . 82,** which would provide flaw information in accordance with the flaws discriminated by the flaw discriminator **72.** The same system, including only the single data router switching control means and the data router gate control, is utilized with the only requirement being an additional discriminator for each type of flaw desired to be routed in a corresponding series of flaw gates equal to the number of strips in which the web is divided.

The output of the flaw gates **24** through **32** may be supplied to counters or other storage means for use merely to count the flaws, or in some instances to shut down the manufacturing process if certain flaws occur exceeding a predetermined frequency or amount.

The data router position switching control means **38** is illustrated utilizing four step-down counters set by thumb wheel switches, but it will be apparent that other forms may be utilized, for example, decade screwdriver settable switches, and the counters may be set to count up to a predetermined level instead of down. The only thing that is necessary is that the data router position switching control means provide a way of presetting a predetermined amount of the scan to effectively divide the web into the desired number of strips or segments. In the illustrated example, five strips have been provided on the web, but it will be apparent that a lesser or larger number may be provided, as desired, merely by using fewer or more presettable counters in accordance with the number of lines to be delineated.

The provision of a data router for a flaw detection system provides flexibility in displaying a variety of flaws without complete duplication of the system. Instead of using separate scanners and receivers and the circuitry connected therewith for providing indication of flaws on discrete intervals along the web, a single scanner and receiver cover the entire web, which is then electrically divided into segments for flaw data information presentation. The adjustable switching feature allows the number and width of the strips to be accurately controlled in a simple and easy manner which, when used with a display normally provided with the system, can be set by simple visual means. It will also be apparent that if flaw information is not desired, for example with the edge strips **1** and **5,** they may be discarded. It will further be apparent that the lines may be set so that flaws will not be indicated until, for example, strip **2** occurs, or strip **2** could be set closer to the edge, if information on the outer edges is not desired.

The foregoing describes how a single scanner and receiver combination can provide a multiplicity of outputs corresponding to divided strips from a given width web of material. If the web width exceeds the scanning capability of a single scanner and receiver combination, it is apparent that additional scanner and receiver systems can be added to cover wider width materials, and their outputs can also be routed in accordance with the present invention. By arranging the active scan widths to lie adjacent to each other without any gaps or overlaps, 100 percent inspection of the wide material surface can be achieved. When data routing with this combination, if a strip is divided between adjacent systems, adjacent portions of the strip will be examined by each system. By means of an OR gate, the separate divided strip flaw signals from each system can be combined to yield a single combined output from the divided strip.

Since other changes and modifications, varied to fit particular operating requirements and environments, will be apparent to those skilled in the art, this invention is not considered limited to the examples chosen for purposes of disclosure, and covers all changes and modifications which do not constitute departures from the true spirit and scope of this invention.

We claim:

1. A data router for a flaw detection system, comprising

a. a source of radiation,

b. a scanner for scanning said source successively over a surface of material being examined,

c. a receiver having a detector means for receiving radiation applied by said source from said surface of material producing signals in response to the intensity of radiation applied to said detector means,

d. flaw discriminator means having said signals from said detector means applied thereto for passing flaw signals of predetermined characteristics in accordance with the requirements of said flaw discriminator means,

e. scan position means coupled to said scanner for indicating the position of said source on said material,

f. data router means coupled to said scan position means for electrically dividing said material into a plurality of strips by producing an output on the occurrence of predetermined demarcation lines delineating different strips on said material as said source is scanned thereacross,

g. a plurality of flaw gates corresponding in number to the number of strips provided by said data router means,

h. means for respectively coupling each of said flaw signals to said plurality of flaw gates, and

i. means for coupling said data router means to said plurality of flaw gates for enabling said flaw gates in succession as said source moves across said material, thereby providing flaw signals from said flaw gates in accordance with their occurrence on a predetermined strip of said material.

2. The structure set forth in claim **1** wherein said data router comprises a data router position switching con-

trol means and a data router gate control means coupled to said switching control means.

3. The structure set forth in claim 2 wherein said data router position switching control means comprises a plurality of presettable counters corresponding in number to the number of demarcation lines desired and producing an output when a preset count is reached.

4. The structure set forth in claim 3 wherein said data router gate control means includes a shift register having outputs coupled to said flaw gates, said shift register being advanced on the occurrence of outputs from said presettable counters.

5. The structure set forth in claim 1 wherein said flaw discriminator means comprises a plurality of flaw discriminator means for passing flaw signals of different electrical characteristics, and said plurality of flaw gates comprises a plurality of groups of flaw gates coupled to each flaw discriminator means for channeling flaw signals of different electrical characteristics in accordance with their occurrence on a preselected strip of said material.

6. The structure set forth in claim 3 wherein said presettable counters are set by thumb wheel switches.

7. The structure set forth in claim 3 wherein said presettable counters are set by screw adjustable decade switches.

8. The structure set forth in claim 1 having a display coupled to said flaw discriminator means and to said data router means providing a visual means for aligning said data router means to divide said material in the desired predetermined strips.

* * * * *