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Cushing et al.

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[54] **FLAW DETECTION AND MARKING APPARATUS**

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[52] **U.S. Cl.** ..... **356/200**, 356/237, 250/219 DF

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

[58] **Field of Search** ..... 356/200, 237, 239; 250/219 DF

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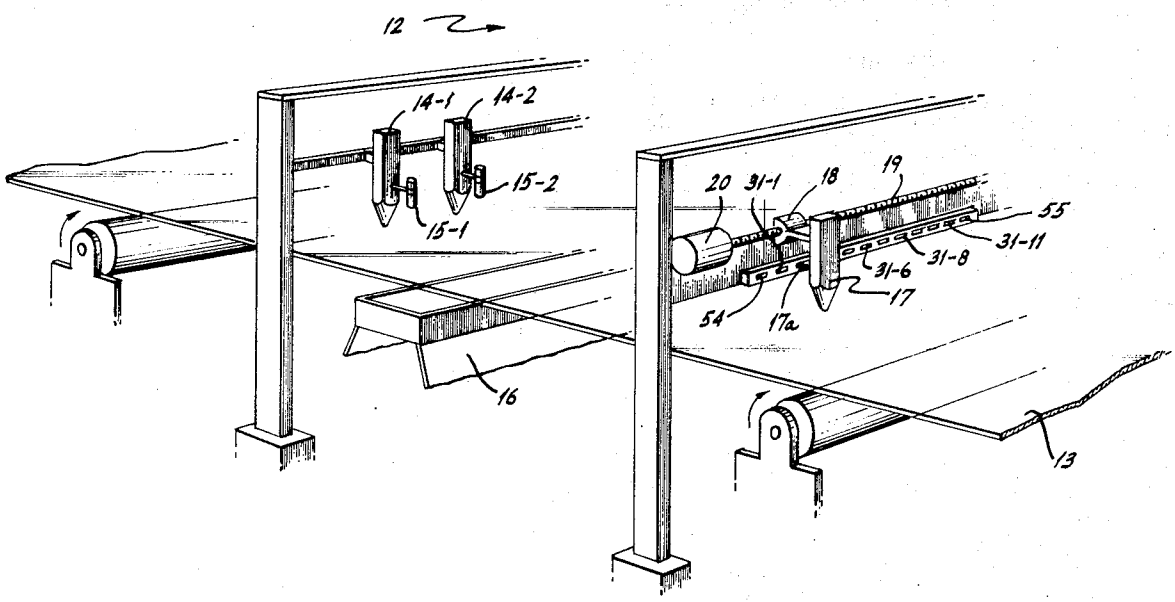
[57] **ABSTRACT**

A flaw detection and marking apparatus for glass including an automatically actuated backup marking device operable to replace any one of a group of primary marking devices in the event of malfunction thereof.

14 Claims, 3 Drawing Figures



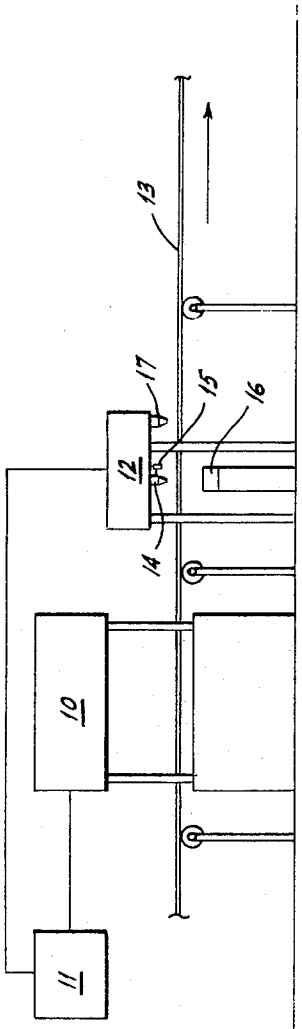

13
17
15
16
12
14
10
11

FIG. 1.

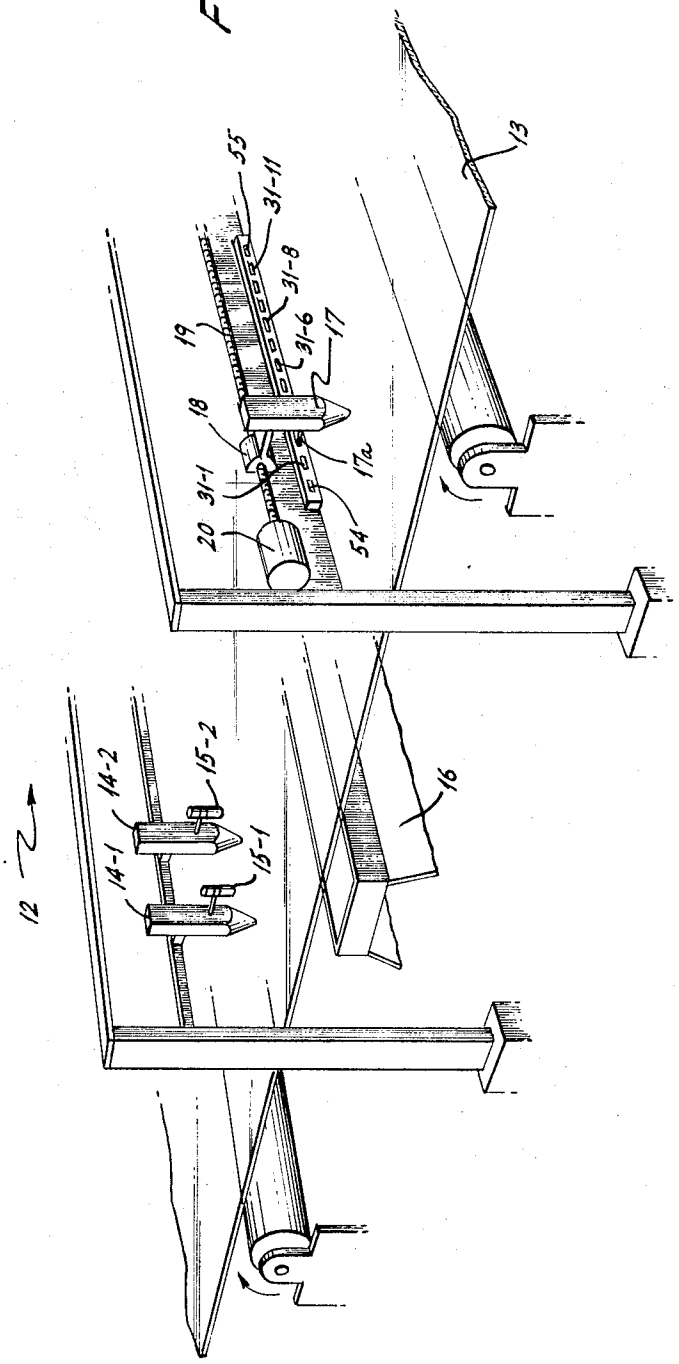

13
55
31-11
31-8
31-6
17
19
18
17a
31-1
20
54
16
14-2
15-2
14-1
15-1
12

FIG. 2.

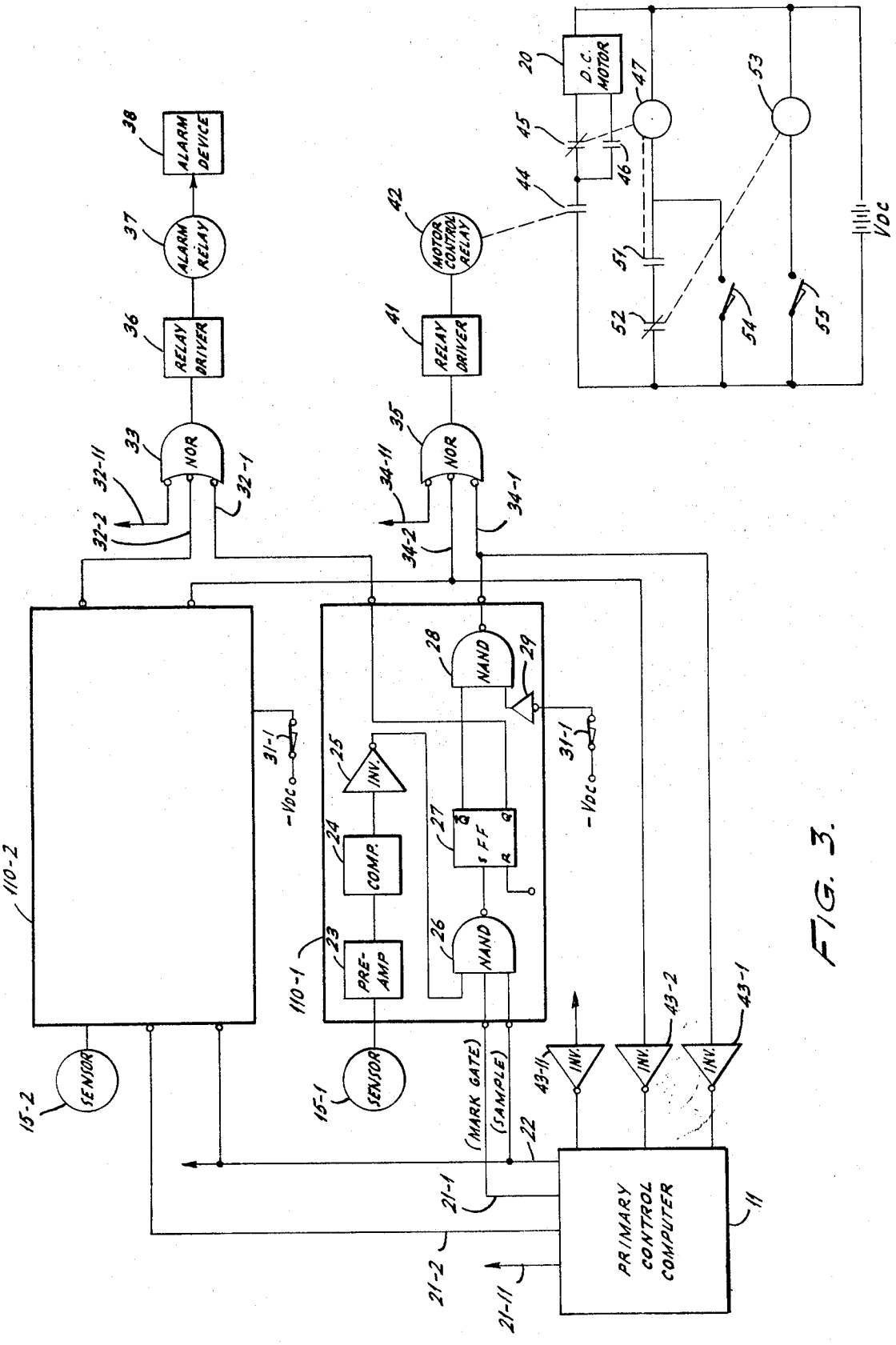

PRIMARY CONTROL COMPUTER
11
21-1
21-2
21-11
(MARK GATE)
(SAMPLE)
22
15-1
15-2
SENSOR
SENSOR
110-1
110-2
PRE-AMP
23
COMP.
24
INV.
25
NAND
26
R S F F
27
NAND
28
29
31-1
-Vdc
31-1
-Vdc
NOR
33
32-11
32-2
32-1
RELAY DRIVER
36
ALARM RELAY
37
ALARM DEVICE
38
NOR
35
34-11
34-2
34-1
RELAY DRIVER
41
MOTOR CONTROL RELAY
42
43-11
INV.
43-2
INV.
43-1
INV.
D.C. MOTOR
20
45
46
47
44
51
52
53
54
55
Vdc

FIG. 3.

FLAW DETECTION AND MARKING APPARATUS

CROSS REFERENCE TO RELATED DISCLOSURE

The present invention is directed to features of construction of a gun marking unit such as is disclosed generally as a part of the broader disclosure contained in copending application Ser. No. 251,832 of Charles J. Cushing et al., filed May 9, 1972, and assigned to the assignee of the present invention.

BACKGROUND OF THE INVENTION

This invention relates to the detection and marking of flaws in a generally planar body of substantially homogeneous material, and more particularly to improvements in means for marking flaws in glass.

Automatically actuated flaw, or defect, marking devices such as guns, crayons, and the like, have found wide usage in the art of glass inspection, wherein the glass moves as a continuous ribbon along a predetermined path and is optically scanned for flaws. Advantages deriving from utilization of such marking devices, in conjunction with apparatus for locating and identifying flaws, are lost in the event the device malfunctions to the extent that a located flaw is poorly marked, or is not marked at all.

It is therefore a general objective of this invention to provide means for overcoming such difficulties as they arise.

It is a further and more specific objective of the invention to provide novel backup marking means capable of automatic operation to mark a glass flaw, in the event a primary marking device malfunctions.

SUMMARY OF THE INVENTION

In achievement of the foregoing as well as other general objectives, the invention contemplates improved flaw marking apparatus useful with detection apparatus of the type including: scanning means for scanning a generally planar body of substantially homogeneous material with a scanning beam and for providing a flaw indication output in response to each irregularity in said body encountered by said scanning beam; and position indicating means for identifying which of a predetermined plurality of areas of said body said scanning element is traversing at each instant. The improved marking apparatus comprises: first marking means for marking each area of said body in which such scanning beam encounters an irregularity; detector means for inspecting said body of material in regions thereof subjected to said first marking means, and effective to determine whether or not a detected flaw has been properly marked; second marking means including a single movable marking device; and means for moving said single marking device to mark an irregularity in response to a signal from said detector means in the event of failure effectively to mark by said first marking means.

The manner in which the foregoing as well as other general objectives and advantages of the invention may best be achieved will be more fully understood from a consideration of the following description, taken in light of the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic showing, in elevation, of the general organization of a glass flaw detection system which includes apparatus embodying this invention;

FIG. 2 is a detailed perspective view of the marking gun unit of this invention, with parts broken away for the sake of convenience; and

FIG. 3 is a circuit diagram of control elements associated with the marking gun unit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With more detailed reference to the drawing, and first to FIG. 1, apparatus embodying the invention includes an optical scanning unit **10**, a control console unit **11**, and a gun marking unit **12**. By way of example, the above apparatus may comprise one of four modules, only one of which is illustrated. Each module is capable of scanning a section of glass 32 inches wide, so that with four such modules, a ribbon of glass 128 inches wide can be inspected continuously as it is moved along a predetermined path.

Each optical scanning unit includes elements disposed above and below the glass **13** undergoing inspection, and comprises a ream and wave flaw subsystem and a metal flaw subsystem, each of which is described in the referenced copending disclosure.

With reference also to FIG. **2**, each gun marking unit **12** comprises eleven solenoid-actuated primary marking guns **14** equally spaced across a section of glass ribbon **13**. For the sake of convenience, only a pair of marking guns **14-1** and **14-2** will be shown. Mounted on the downstream sides of marking guns **14-1**, **14-2**, are photodetectors **15-1**, **15-2**, each aligned with the nozzle of its gun, and directed toward the glass **13** and at a source of light **16** beneath the latter.

In especial accordance with the invention, a backup marking gun **17** is positioned downstream of primary marking guns **14-1**, **14-2** and is capable of being selectively located to substitute for any one of the eleven primary guns.

Backup gun **17** is mounted by a ball nut **18** on a lead screw **19** that extends transversely of the path of travel of the glass ribbon. Lead screw **19** is driven by a selectively reversible D. C. motor **20**, in provision for selective positioning of gun **17**. A group of eleven normally closed limit switches **31-1** to **31-11**, each corresponding to a position of a primary gun **14-1** to **14-11**, and a pair of normally open end limit switches **54**, **55**, are operable by a cam **17***a* on gun **17**. The function of these switches will be described in detail in connection with FIG. **3**.

With reference to FIG. **3**, the primary control computer unit **11** includes position indicating means, of known type, for identifying which of a predetermined plurality of areas the scanning unit is traversing at each instant, a sampling pulse terminal **22**, ane eleven mark gate terminals **21-1** to **21-11**, one in correspondence to each of the eleven primary marking guns **14-1** to **14-11**. One of eleven identical mark sampling unit computers is shown in detail at **110-1**, and since operation of each such computer is identical to the other, description of operation of the system will be made in light of the single computer **110-1** and those of the other duplicate elements associated therewith. To aid in an understanding of the duplication of elements, block **110-2** is shown with its connection made to leads or terminals identified in correspondence with leads connected to block **110-1**, but which terminals bear the suffix **2**. Leads bearing arrows and suffix **11** are illustrative of

the remaining elements, including suffixes 3 to 10 which have been omitted to simplify the illustration.

Photodetector 15-1 is in series electrical circuit with elements of computer 110-1, which includes a preamplifier 23, a comparator 24, an inverter 25, and a terminal of a three-input NAND gate 26. The aforementioned terminals 21-1 and 22 are connected to the other two input terminals of NAND gate 26, and the output terminal of the latter is connected to the input terminal S of flip-flop 27 whose $\overline{Q}$ output terminal is connected to a two-input NAND gate 28. Flip-flop 27 is the type commonly known as an R-S flip-flop. In its reset or normal state the $\overline{Q}$ output is high and the Q output is low. The R input is normally held high. When the S input is made low the flip-flop is set and the Q output becomes low and the $\overline{Q}$ output becomes high. The flip-flop is reset again by momentarily setting the R input low while the S input is high. In the arrangement of circuits thus far described, NAND gate 26 serves as a mark coincidence logic element.

If, upon detection of a flaw, the desired primary marking gun 14 is energized, and an ink mark is placed on the glass, a MARK GATE signal is applied through terminal 21-1 to the gate of mark coincidence logic element 26.

As the ink mark passes between the sensor 15 and the light source 16, the sensor will change its impedance state, in relation to the density of the ink mark. If the mark is of acceptable density, as determined by comparator 24, a signal is applied through inverter 25 to a gate of the mark coincidence logic element 26. At a time location that is coincident with the center of the mark spray, a SAMPLE pulse is applied through terminal 22 to a gate of the mark coincidence logic element 26. If the mark is acceptable, no transition of the mark coincidence logic element 26 will occur. If an unacceptable mark is present, or a mark is missing, logic element 26 will change state during the sampling pulse period.

There are two output terminals of computer 110-1, one terminal connecting the Q terminal of flip-flop 27 to input terminal 32-1 of an eleven-input NOR gate 33, and the other terminal connecting the output of NAND gate 28 to input terminal 34-1 of an eleven-input NOR gate 35. The output of NOR gate 33 is connected in series circuit with a relay driver 36 and an alarm relay 37 for a suitable alarm device 38. The output terminal of NOR gate 35 is connected in series circuit with a relay driver 41 and a control relay 42 for motor 20. Normally closed limit switch 31-1 is connected to a source of D.C. voltage (− V D.C.) and to the other input terminal of NAND gate 28 through inverter 29. The output terminal of NAND gate 28 is also connected to the input of an inverter 43-1, the output of which inverter is connected to the matrix control elements of primary control unit 11.

As mentioned above, motor 20 is of the D.C. type, and is reversible. It is connected to a suitable source of D.C. voltage (V D.C.) through normally open contacts 44 of relay 42, which contacts 44 are in series circuit with parallelly connected normally closed contacts 45 and normally open contacts 46 of a relay 47. The latter relay 47 is connected to a source of D.C. voltage through a parallel circuit including normally open contacts 51 of relay 47 and normally closed contact 52 of relay 53 in series, and normally open extreme limit switch 54 for backup marking gun 17. Relay 53 is connected to the D. C. voltage source through the other normally open limit switch 55 for gun 17.

Further to the operation, a change in state of the mark sampling logic element 26 will set the flip-flop 27. The set state of flip-flop 27 will then activate the motor control relay 42, through NAND gate 28, NOR gate 35 and relay driver 41, and will activate the alarm indicator relay 37, through NOR gate 33 and relay driver 36. The output signal from NAND gate 28 will also set up the computer matrix 11, through inverter 43-1, to provide information to the backup gun 17 when in its proper position for marking.

Activation of the motor control relay 42 closes relay contacts 44 to provide power to D. C. motor 20, to rotate it in one direction. Energization of the D. C. motor causes backup gun assembly 17 to be traversed, by rotation of lead screw 19. Direction of travel, i.e. direction of rotation of motor 20, is determined by means of relay 47 and its relay contacts 45, 46. Reversal is achieved at either of the extreme ends of traverse by actuation of one of limit switches 54 and 55 to energize one or the other of relays 47 and 53, and operate the associated ones of relay contacts 45, 46, 51 and 52 to reverse the polarity of the applied D. C. voltage, hence reverse the direction of the D. C. motor rotation.

As the backup gun 17 is traversed, when the motor control relay 42 is energized to cause motor 20 to run, cam 17*a* attached to the backup gun assembly will sequentially and momentarily open each of normally closed limit switches 31-1 to 31-11 positioned in alignment with the primary marking guns 14, in the direction of glass flow.

When that one of the switches 31-1, etc. located behind the faulty one of primary guns 14-1 etc., is opened, a pulse is applied to input terminal 34-1, etc., of the location coincidence logic element, i.e. NOR gate 35. If a low input has been fed to NAND gate 28, a change in state of element 35 will occur to de-energize the motor control relay 42, causing the traversing motor 20 to stop. This positions the backup gun 17 behind the faulty one of guns 14, and enables the computer matrix 11 to allow marking information to be applied to the backup gun. Also, alarm device 38, such as a light, buzzer, or the like, is activated to signal that one of the primary guns is malfunctioning.

Once the backup gun assembly 17 has traversed and located itself behind a faulty unit, it will continue to function in that location even after the repair or replacement of the faulty primary gun, until the logic flip-flop 27 has been reset through application of an appropriate signal through its input R, in accordance with known practice. Once reset, the backup assembly 17 is idle and is capable of being activated to a different location.

Summarizing, it will be appreciated that the invention ensures that a group of unattended, primary flaw marking devices for transparent material such as glass, plastic material, or the like, are backed up by a similar marking device operable automatically to position itself to take over the function of a faulty primary marking device. Each mark made by a primary marking device is sampled and analyzed for acceptability. If unacceptable, controls are activated to set in motion the backup marking device which, in the preferred embodiment, is traversed to the position of the faulty primary marking device, and functions in place of the latter while activating the alarm device. Marking control

and delay are provided by computer elements **110-1**, etc., and **11**, which are provided with information necessary for activating the proper marking devices. Necessary matrix controls are provided in the computer elements so that the backup marking device will receive the proper marking activation signals when positioned in place of a faulty primary marking device.

We claim:

1. In flaw detection and marking apparatus of the type including means for scanning a body of substantially homogeneous material with a scanning beam and means for providing a flaw indication output in response to each irregularity in said body encountered by said scanning beam, and position indicating means for identifying which of a predetermined plurality of areas of said body said scanning beam is traversing at each instant, the improvement comprising: first marking means for marking each area of said body in which said scanning beam encounters an irregularity; detector means for inspecting said body of material, in regions thereof subjected to said first marking means, and operable to generate a signal in response to failure of said first marking means effectively to mark; second marking means including a movably mounted marking device; and means for moving said movably mounted marking device to mark the body undergoing inspection, in the region of an irregularity therein, in response to said signal.

2. Apparatus according to claim **1**, and characterized in that said body of material is transparent, and said detector means comprises: photodetector means aligned with said first marking means, and disposed to one side of said body of material; and a source of light disposed to the other side of said body of material and directed therethrough toward said photodetector means.

3. Apparatus according to claim **1**, and characterized in that said second marking means comprises: nut means for supporting said marking device; lead screw means extending generally transversely of said body of material and engaged by said nut means; motor means for driving said lead screw means; and limit switch means operable by said marking device in positions thereof aligned with said first marking means and effective to de-energize said motor means upon arrival at a position where a flaw indication signal is present.

4. Apparatus according to claim **3**, and further characterized in that said motor means is of the reversible type; and including end limit switch means engageable by said marking device at opposite ends of its travel in a region defined by said first recited limit switch means, such engagement being effective to reverse the direction of rotation of said motor means.

5. Apparatus according to claim **2**, and characterized in that said signal is derived from the output of said photodetector means in combination with signals derived from said flaw indication output and said position indicating means.

6. Apparatus according to claim **2**, and characterized in that said means for generating a signal includes, in series electrical circuit with said photodetector means: a preamplifier; a comparator; an inverter; and one terminal of a three-input NAND gate, the output terminal of the latter being connected to the input terminal of a flip-flop having a $\overline{Q}$ and a Q output terminal; said means for generating a signal further including: a two-input NAND gate and a connection between the $\overline{Q}$ terminal of said flip-flop and one input terminal of said NAND gate; a NOR gate; a connection between the output terminal of said NAND gate and one input terminal of said NOR gate; a relay driver and a motor control relay connected in series electric circuit, and a connection between the output terminal of said NOR gate and said relay driver; an inverter; a connection between the output terminal of said inverter and the other input terminal of said two-input NAND gate; means for producing a signal at each of the stations traversed by said movably mounted marking device; a connection between said means for producing a signal and the input of said inverter; means for producing a signal indicative of a flaw mark applied by said first marking means, and a connection from said means for producing a signal to a second input terminal of said three-input NAND gate; and means for generating a sampling pulse having a terminal connected to the third input terminal of said three-input NAND gate, said pulse being generated at an instant of time a detected flaw is aligned with said movable marking device.

7. Flaw detection and marking apparatus for a substantially planar body of transparent material, comprising: means for scanning said body; means for providing a flaw indication output in response to each irregularity in said body encountered by said means for scanning; position indicating means for identifying which of a predetermined plurality of areas of said body said means for scanning is traversing at a given instant; first marking means for marking each area of said body in which said means for scanning encounters an irregularity; detector means operable to inspect said body of material, in regions thereof subjected to said marking means, to determine whether or not a detected flaw has been effectively marked; second marking means including a movably mounted marking device; and means for moving said movably mounted marking device to mark the body undergoing inspection in the region of an irregularity therein, in response to a signal derived from said detector means in combination with signals derived from said flaw indication output and said position indicating means.

8. Apparatus according to claim **7**, and characterized in that: said body of material is caused to move along a predetermined path and said means for scanning is operable to scan said body in a direction transverse its path of travel; said marking means comprises a plurality of individual marking devices spaced transversely of the direction of movement of said body and located downstream of said means for scanning; and said movably mounted marking device is positioned downsteam of said marking devices and movable in a direction transverse the direction of movement of said body, to a backup position aligned with one of said individual marking devices.

9. Apparatus according to claim **8**, and characterized further by the inclusion of alarm means operable, upon detection of an ineffectively marked irregularity in said body of material, to signal malfunctioning of a marking device.

10. Apparatus according to claim **8**, and characterized further in that said detector means comprises: a plurality of photodetectors each aligned with one of said individual marking devices, and disposed to one side of said body of material and intermediate said individual marking devices and said movably mounted marking device; and a source of light disposed to the

other side of said body of material and directed therethrough toward said photodetectors.

11. Apparatus according to claim **10**, and further characterized in that each said photodetector is carried by a corresponding one of said individual marking guns with which it is aligned.

12. Flaw detection and marking apparatus for a substantially planar body of transparent material, comprising: means for scanning said body; means for providing a flaw indication output in response to each irregularity in said body encountered by said means for scanning; position indicating means for identifying which of a predetermined plurality of areas of said body said means for scanning is traversing at a given instant; first marking means for marking each identified area of said body in which said means for scanning encounters an irregularity; detector means for inspecting said body of material, in regions thereof subjected to said marking means, and operable to generate a signal in response to failure of said first marking means effectively to mark; second marking means including a movably mounted marking device; and means for moving said movably mounted marking device, in response to said signal, to mark the body undergoing inspection in the region of an irregularity therein.

13. In flaw detection and marking apparatus of the type including means for scanning a body of substantially homogeneous material with a scanning beam and means for providing a flaw indication output in response to each irregularity in said body encountered by said scanning beam, and position indicating means for identifying which of a predetermined plurality of areas of said body said scanning beam is traversing at each instant, the improvement comprising: first marking means for marking an identified area of said body in which said scanning beam encounters an irregularity; second marking means including a movably mounted marking device; means for moving said movably mounted marking device to mark the body undergoing inspection, in the region of an irregularity therein, in response to a predetermined signal; and detector means for inspecting said body of material in regions thereof subjected to said first marking means, and operable to generate the recited predetermined signal in response to failure of said first marking means effectively to mark.

14. Apparatus according to claim **13**, and characterized in that said detector means comprises: a photosensor for looking at an identified area of said body which has been subjected to said first marking means; means defining a threshold detector coupled to said photosensor and operable to generate a first signal upon sensing failure of said first marking means; means for generating a second signal upon operation of said first marking means; means for generating a third signal coincident with disposition of the stated identified area in alignment with said photosensor; first means defining a coincidence circuit for receiving said first, second, and third signals as input and effective thereupon to generate a fourth signal as an output; second means defining a coincidence circuit for receiving as input said fourth signal and a fifth signal corresponding to lack of the desired location of said second marking device, said second means effective thereupon to generate the recited predetermined signal.

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