United States Patent

Watson et al.

[15] **3,694,658**

[45] **Sept. 26, 1972**

[54] VENEER INSPECTION SYSTEM

[72] Inventors: **Gerald L. Watson**, Tigard; **Don Latshaw**, Portland, both of Oreg.

[73] Assignee: **Morvue, Inc.**, Tigard, Oreg.

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

[21] Appl. No.: **83,075**

[52] **U.S. Cl.**.....**250/219 DF**, 250/219 WE, 250/227, 356/199, 356/237

[51] **Int. Cl.**.....**G01n 21/30**

[58] **Field of Search**.....250/219 F, 219 R, 219 D, 219 FR, 250/219 WE, 219 DF, 227; 350/96; 356/199, 200, 237, 238

[56] **References Cited**

UNITED STATES PATENTS

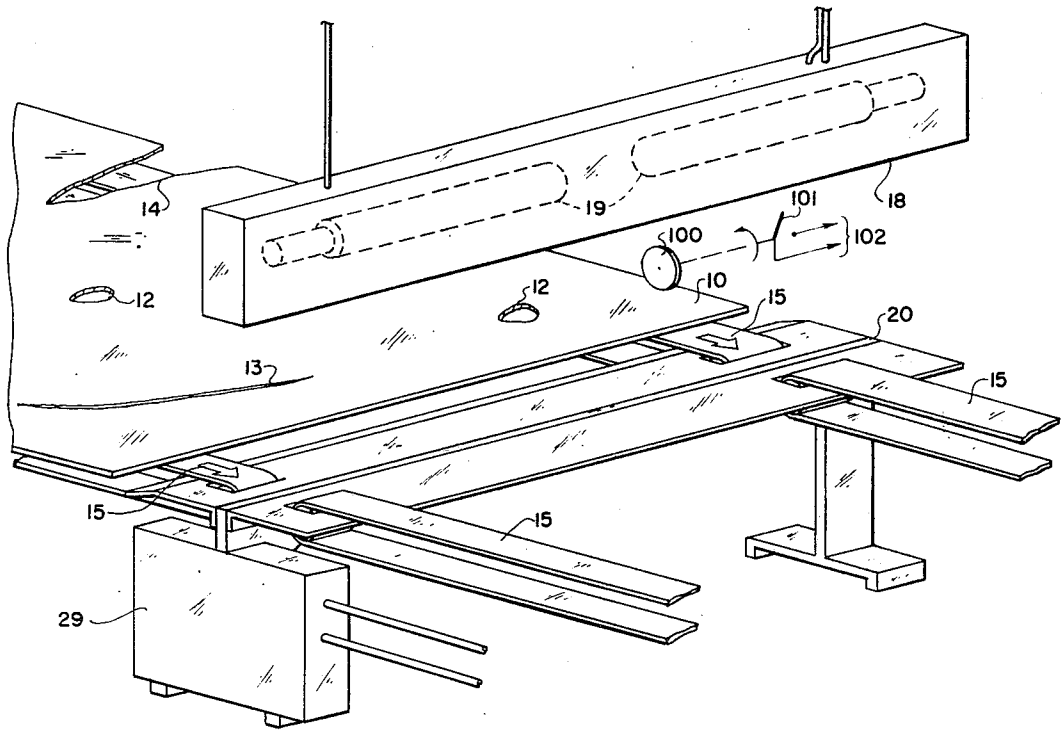
3,560,096	2/1971	Watson	356/237
3,436,757	4/1969	Schwab	250/227
3,188,478	6/1965	Binks	250/227
3,444,358	5/1969	Malone	250/219 D
3,432,676	3/1969	Lindberg	250/219 D
3,428,817	2/1969	Hofmeister	250/219 LG
3,311,749	3/1967	Briggs	250/227
3,413,065	11/1968	Funk	250/219 F
3,411,008	11/1968	Coombes	250/219 DF
3,389,789	6/1968	Watson	250/219 DF
3,331,963	7/1967	Lippke	250/219 DF

Primary Examiner—James W. Lawrence
Assistant Examiner—D. C. Nelms
Attorney—Daniel P. Chernoff

[57] **ABSTRACT**

On-line apparatus for inspecting a moving strip of veneer for the presence of cracks, knotholes, voids and similar type wood defects utilizing light transmission through the material to detect discontinuities therein. Light radiation transmitted through such a wood defect is detected by a scanner head formed of a plurality of flexible, light-conducting optical fibers whose terminal ends are positioned adjacent the surface of the veneer strip on the side opposite the light source and at spaced locations along the transverse width of the strip. The detected light radiation is conveyed by the flexible fibers to a corresponding array of photoelectric transducers which are strobe interrogated in serial sequence so as to generate as an output a composite waveform indicative of the light transmissibility pattern of the cross-section of veneer strip passing over the scanner head at the instant of the strobe. This strobe interrogation process is repeated at regular close intervals, so as to generate successive waveforms representative of the character of the wood strip passing over the scanner head. The presence of through-wood defects produces corresponding variations in the successive waveform outputs of the photosensor array which, after digitizing, are fed into arithmetic and logic circuitry. Counter and comparator elements operate on this digital information to measure the cross-grain and with-grain dimensions of individual defects and generate an actuating signal when a defect exceeds predetermined dimensional limits. The logic circuitry distinguishes cracks and splits on the one hand, which have large with-grain and quite narrow cross-grain dimension, from knotholes and other voids in the wood having substantially larger cross-grain dimension than cracks or splits.

3 Claims, 11 Drawing Figures



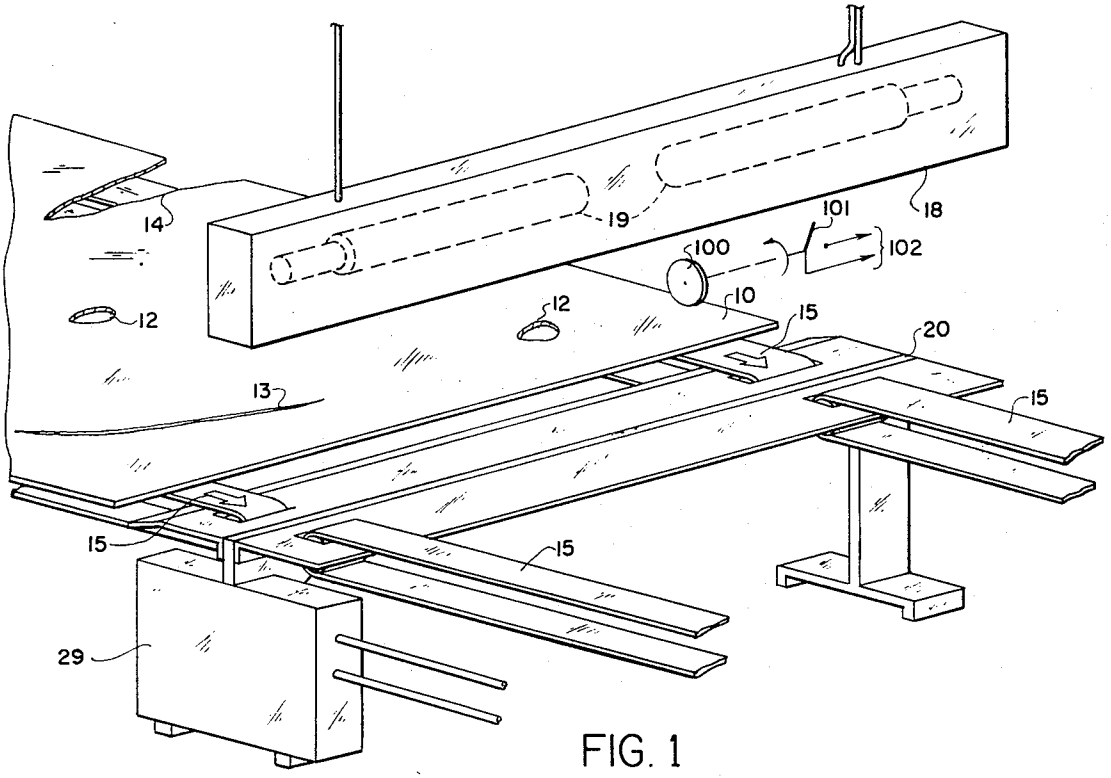

14
19
18
101
100
102
12
12
10
15
20
13
15
15
15
29

FIG. 1

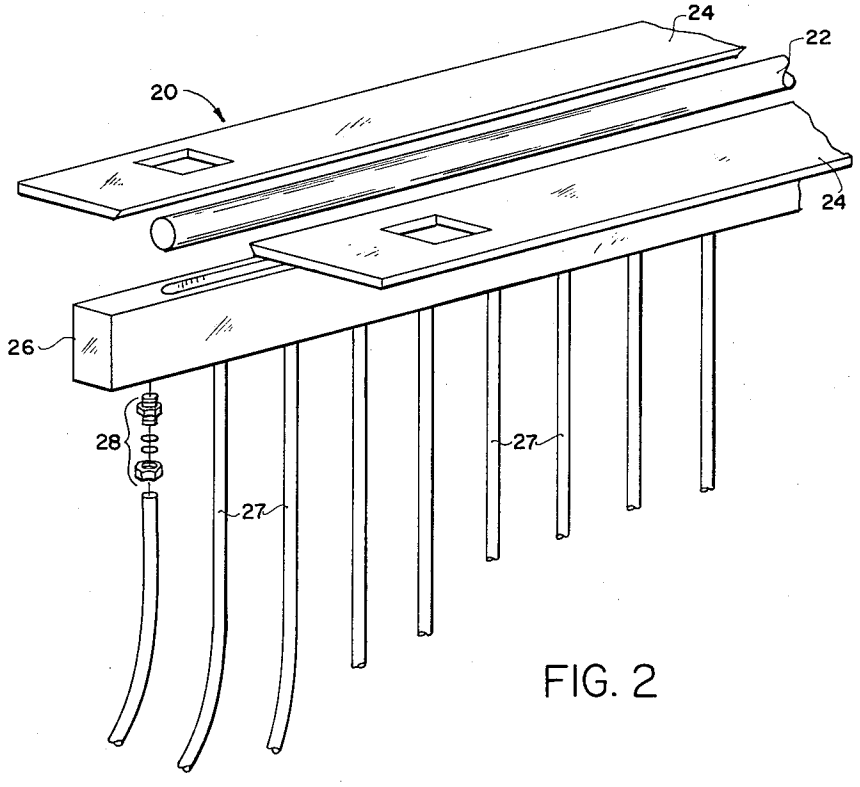

24
22
20
24
26
28
27
27

FIG. 2

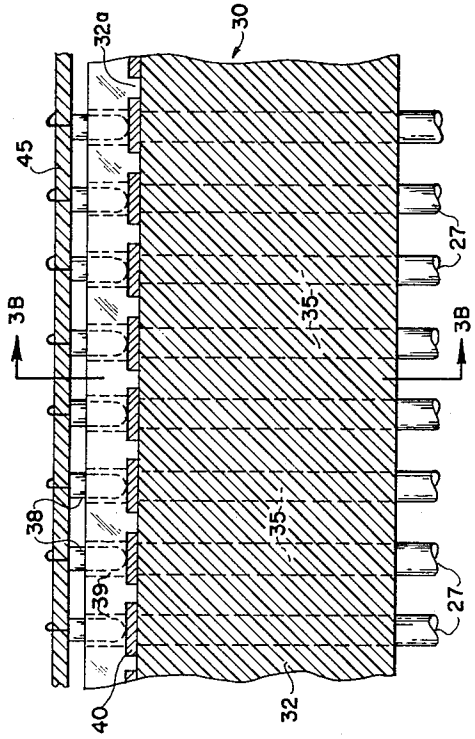


FIG. 3A

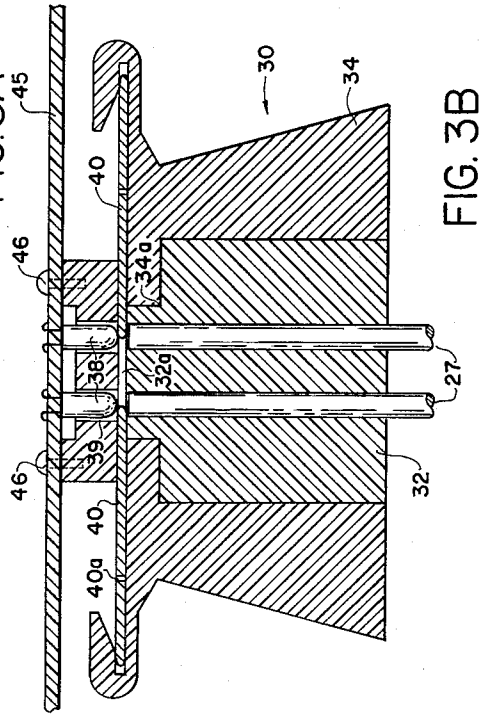


FIG. 3B

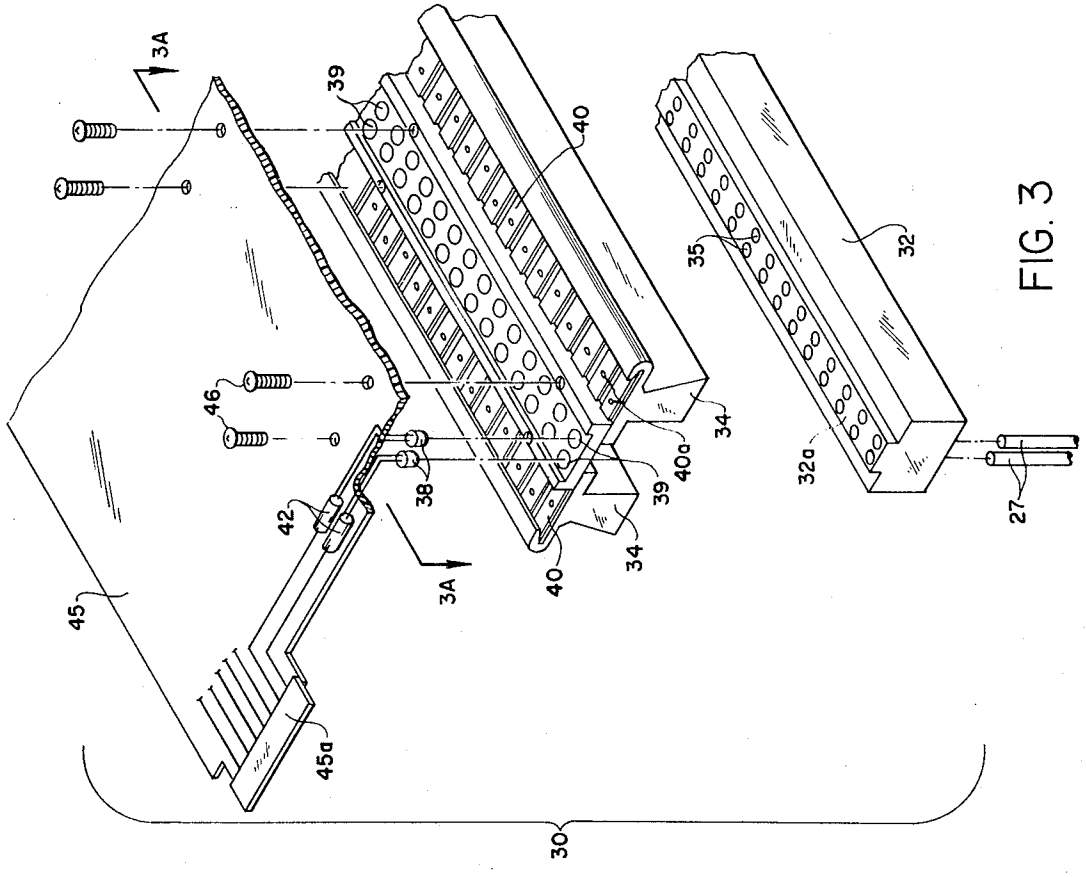


FIG. 3

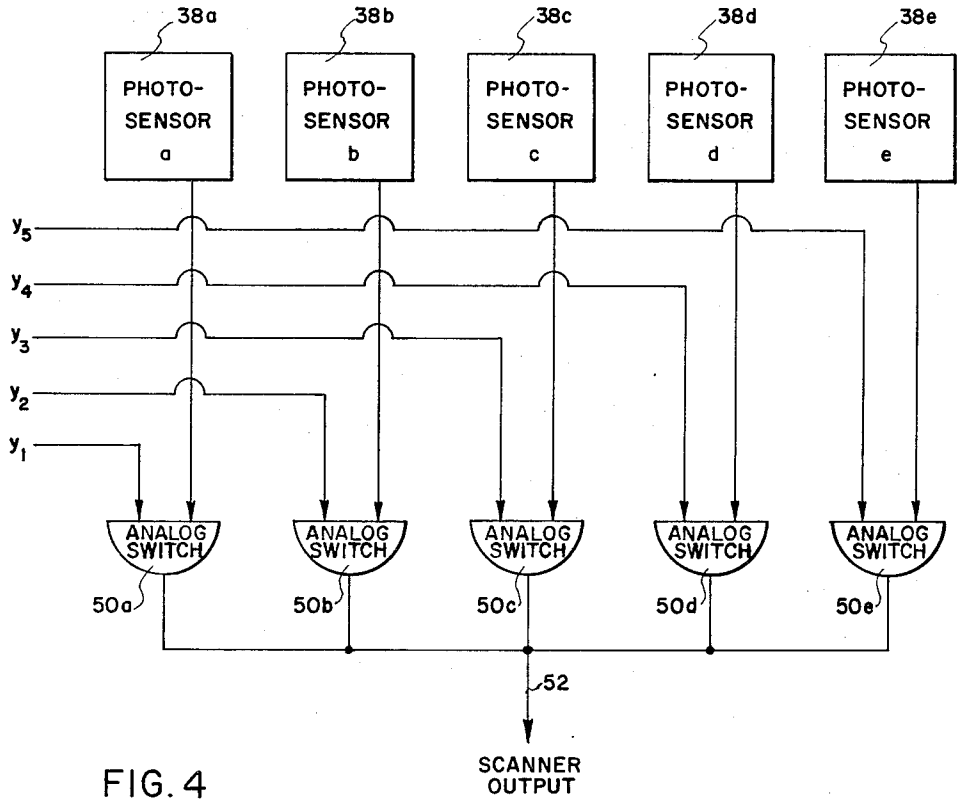


FIG. 4

STROBE PROCESS

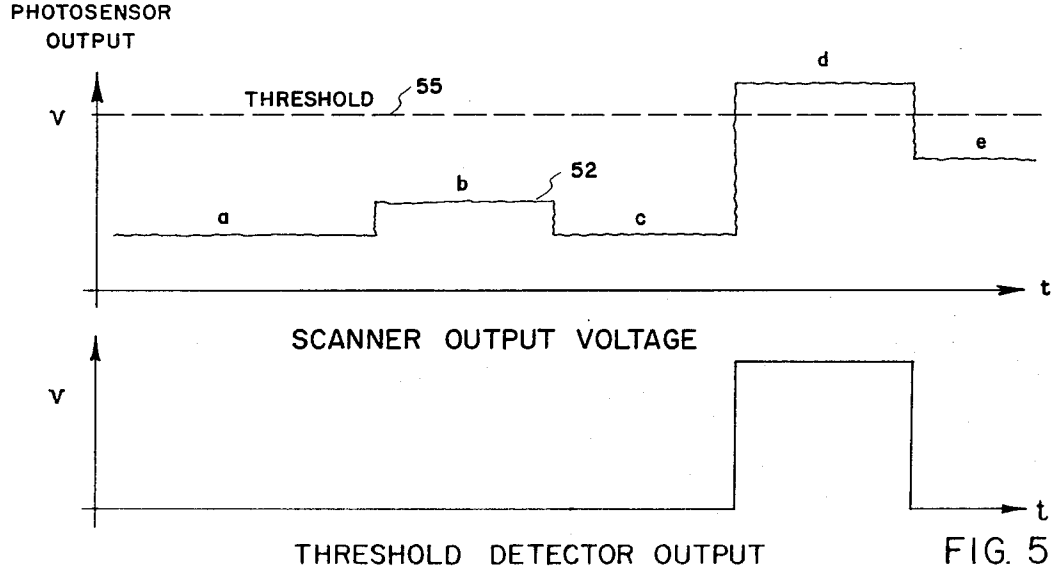


FIG. 5

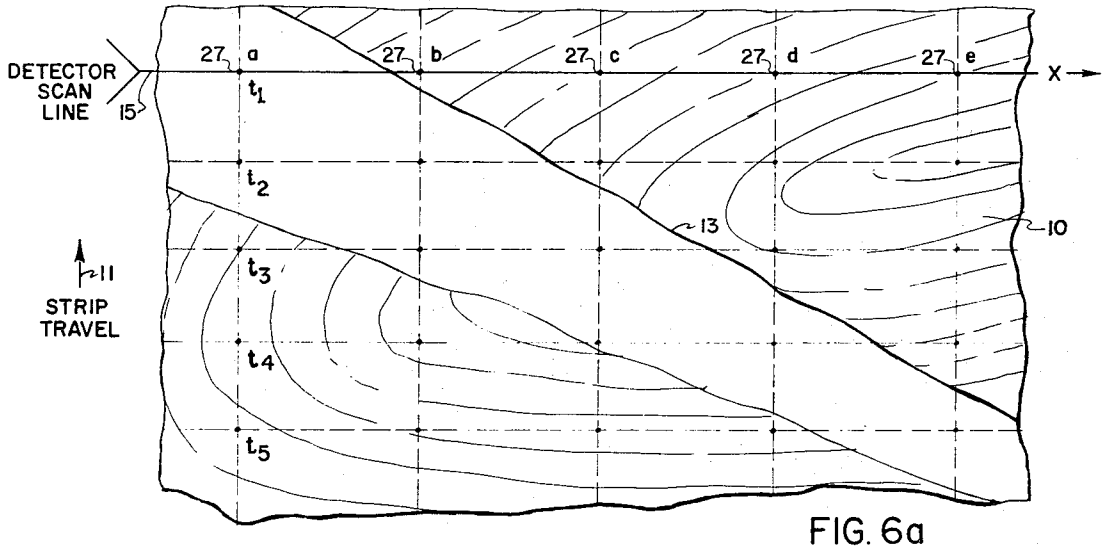


FIG. 6a

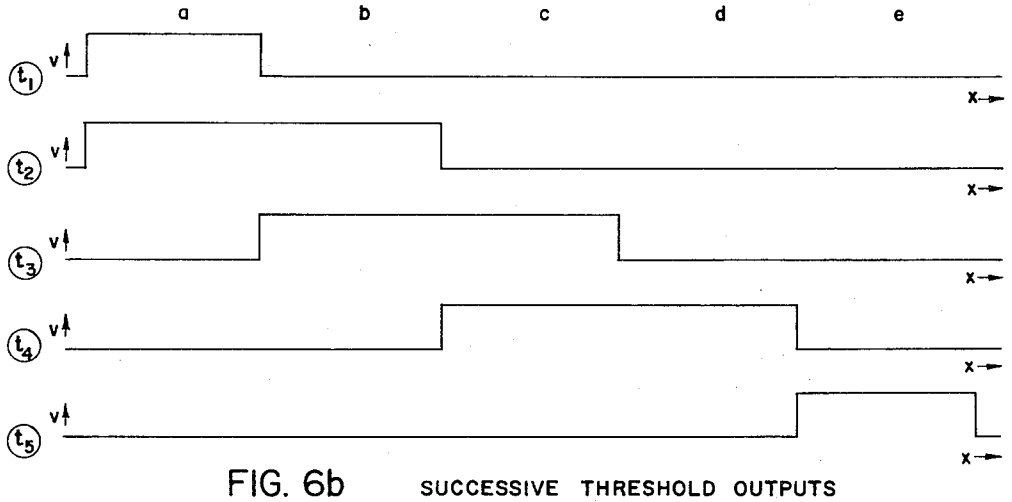


FIG. 6b SUCCESSIVE THRESHOLD OUTPUTS

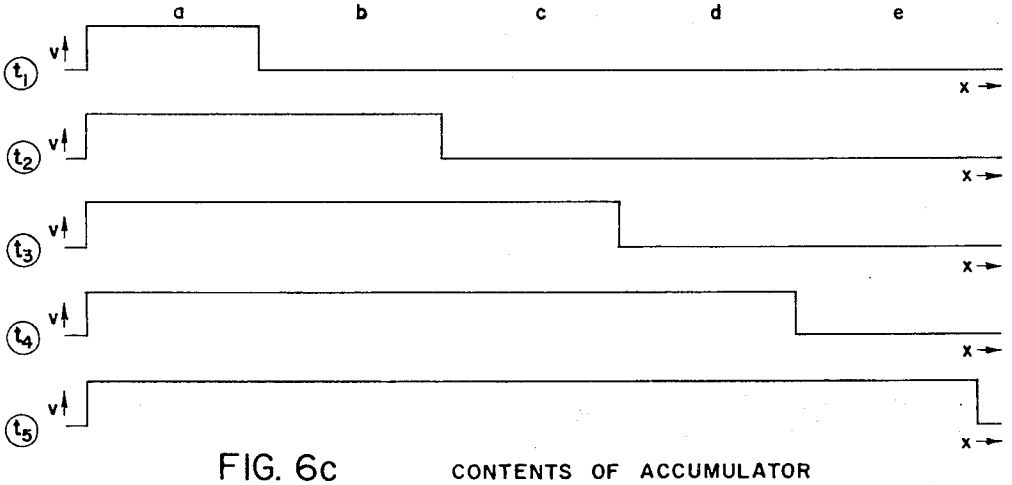


FIG. 6c CONTENTS OF ACCUMULATOR

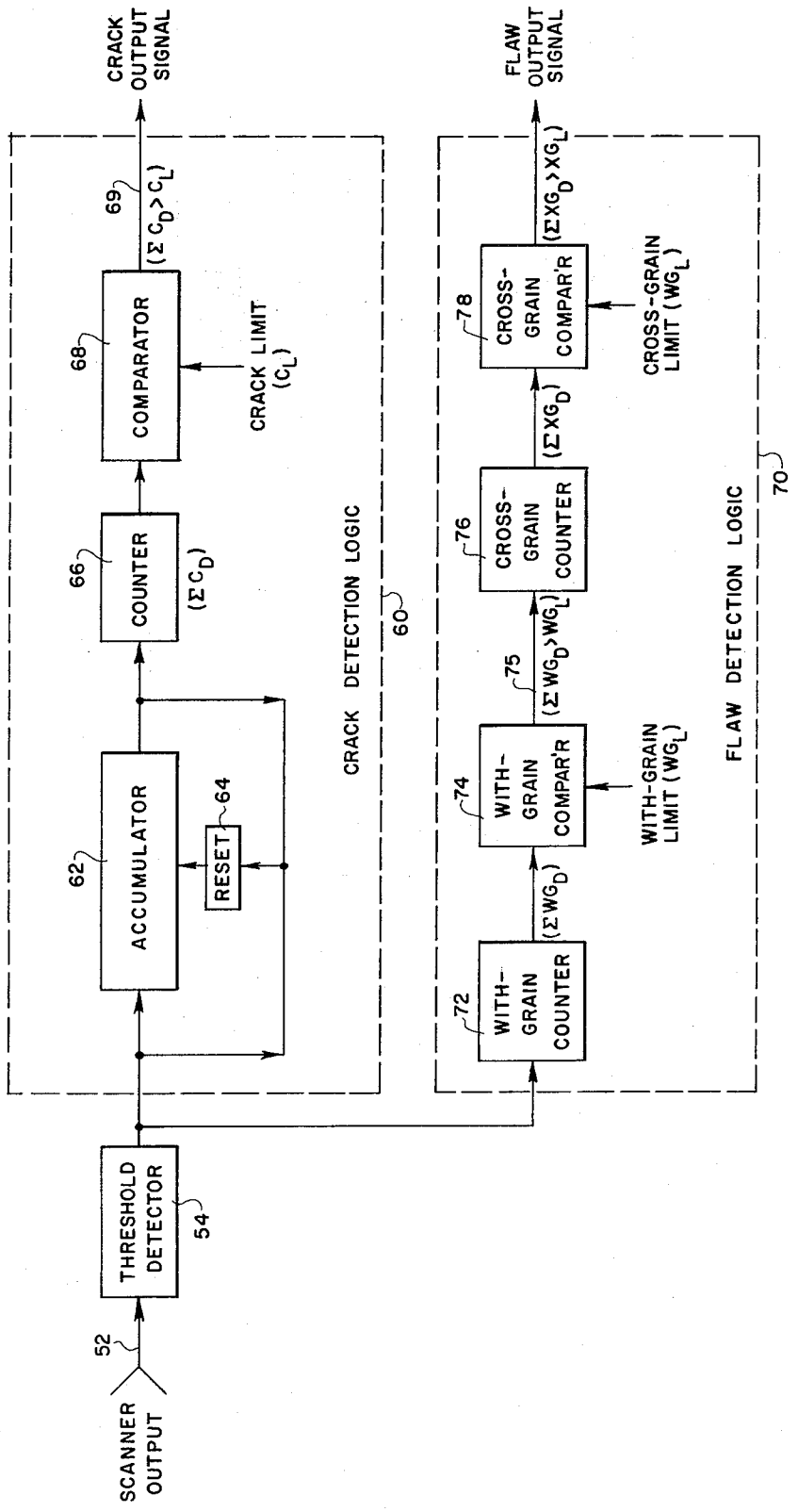

SCANNER OUTPUT
52
THRESHOLD DETECTOR
54
ACCUMULATOR
62
RESET
64
COUNTER
66
(ΣC_D)
COMPARATOR
68
CRACK LIMIT (C_L)
69
$(\Sigma C_D > C_L)$
CRACK OUTPUT SIGNAL
CRACK DETECTION LOGIC
60
WITH-GRAIN COUNTER
72
(ΣWG_D)
WITH-GRAIN COMPAR'R
74
WITH-GRAIN LIMIT (WG_L)
75
$(\Sigma WG_D > WG_L)$
CROSS-GRAIN COUNTER
76
(ΣXG_D)
CROSS-GRAIN COMPAR'R
78
CROSS-GRAIN LIMIT (WG_L)
$(\Sigma XG_D > XG_L)$
FLAW OUTPUT SIGNAL
FLAW DETECTION LOGIC
70

FIG. 7

VENEER INSPECTION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to apparatus for on-line inspection of moving veneer strip for through-wood defects, and more particularly relates to veneer inspection apparatus with means for measuring the size of such defects and generating an actuating signal output when the dimensions of a defect exceed predetermined limits.

In the production of wood veneer, wherein a ribbon of wood of typically one-tenth to two-tenths of an inch thickness is peeled from a log by a veneer lathe, there inevitably appear on the veneer strip at regular and irregular intervals various dicontinuities or through-wood defects in the form of cracks, splits, knotholes, fishtails, voids and the like. Depending upon the size of such defects, both in their with-grain and cross-grain dimensions, it is desirable, in accordance with industry practice, to clip them out from the traveling strip with a veneer knife when the defect exceeds certain tolerance limits.

Until fairly recently the operation of the veneer knife was under the manual control of a human operator (the clipperman) who visually monitored the quality and character of the veneer strip and actuated the guillotine-like knife to cut out the unacceptable portions of veneer containing oversized wood defects. Because of the speed of the strip travel, as well as the frequency of the clipping action required of the operator, considerable wood wastage occurred as it was impossible for the operator to cut the wood at precisely the leading and trailing edges of the defect, thus leaving sizeable marginal bands of good wood on either side which would be clipped out with the defect. Also, the operator was subject to fatigue and human error, thereby increasing the possibility that sizable amounts of good wood would be wasted in the clipping process. Moreover, the decision of the clipperman, as to whether to clip out or leave in a small defect not clearly exceeding the prescribed tolerance limits was a subjective one and accordingly susceptible to variation from time to time with the same operator and from shift to shift with different operators. Finally, it was essential for best clipping results that the travel of the veneer strip be at a relatively slow speed within the ability of the clipper operator to visually scan the veneer for defects as it passed beneath his gaze. Consequently, veneer clipping, when carried out by human operators, is an inefficient, tedious; wasteful and costly process.

Apparatus has recently been devised by applicants' assignee, marketed under the trademark Autoclip and disclosed in its Watson et al U.S. Pat. No. 3,560,096, in which veneer strip is inspected for wood defects by electro-optical means and the clipper knife actuated automatically when a defect exceeds certain predetermined dimensional limits. In this prior apparatus defects are detected by monitoring the variations in light intensity reflected from the surface of the wood as it passes beneath an illumination source. While this device performs satisfactorily, it is of somewhat intricate and expensive construction since it is necessary to employ a relatively complex optical arrangement and computer circuitry in order to enable the system to compensate for stain and similar variations in reflected light intensity caused by surface discolorations in the

veneer from through-wood defects such as knotholes, cracks, voids and the like which deleteriously affect its structural integrity and strength.

In order to simplify the design and lower the cost of an automatic inspection system capable of reliably detecting and monitoring the size of through-wood type defects in veneer strip as it travels by at a high rate of speed so as to generate an actuating signal for the clipper knife when a defect exceeds predetermined dimensional limits, the present applicants have devised a novel apparatus utilizing a scanner head positioned beneath the traveling veneer strip on the side opposite an illumination source and responsive to light radiation passing through the wood at those places where throughwood type defects are present. In this manner the complexities introduced in the aforementioned prior art device occasioned by surface discolorations and irregularities not materially affecting the structural integrity of the material are inherently eliminated, thus greatly reducing the cost of the veneer inspection system, with the only sacrifice in system response being with respect to detecting superficial wood irregularities and surface discolorations which are of usually lesser importance.

SUMMARY OF THE INVENTION

The present invention is directed to a veneer inspection system in the form of apparatus for detecting and monitoring the size of through-the-wood defects in a moving strip of veneer and for generating an actuating signal for controlling a clipper knife when a defect exceeds predetermined limits either on its with-grain size or on a combination of its with-grain and cross-grain size. The apparatus utilizes an illumination source on one side of the wood strip and a scanner situated on the other side responsive to light energy transmitted through any openings appearing in the material passing between. The scanner is comprised of a head element formed of a glass rod, extending laterally of the veneer strip and contacting the underside of the wood, to which are connected at closely spaced intervals along the length of the rod the terminal ends of a plurality of light-conducting optical fibers. The array of optical fibers receives any light energy transmitted through any respectively opposed openings appearing in the veneer strip as it passes over the rod and transmits the light to a corresponding array of photo-electric transducers which convert the incident light energy to an electrical output.

The electrical signals derived from the respective outputs of the individual photosensors are representative of the pattern of light energy transmitted through openings appearing in the wood material as it passes over the scanner head. These photosensor signals are then converted into a serial pulse train waveform by periodic strobe interrogation of the sensors in sequence under control of a timing clock pulse followed by digitizing of the information so obtained through the use of a threshold detector limiter. Thus, at regular intervals of incremental advance of the veneer strip past the scanner head, a pulse train is generated which is representative of the instantaneous light transmisson pattern across the width of the veneer at the plane of the scanner head. (Generally speaking, the pulse train representative of the light transmissibility pattern is in

binary bit form since, at each detection point in the scanner head along the width of the veneer, the light from the illumination source at any given instant of time is either blocked by the wood or is substantially or wholly transmitted therethrough due to the presence of a void or discontinuity in the wood at that point.) The pulse train waveforms generated by the photosensors are supplied to suitable arithmetic and logic circuitry which count the number of pulses in a given train (indicative of the with-grain size of a defect) and compare successive pulse trains (indicative of the cross-grain size of a defect), and then in turn compare these readings with preset dimensional limits to generate output signals when tolerances are exceeded. In the foregoing manner the traveling veneer strip is constantly monitored by the apparatus for the presence of through-wood defects, their size noted and an actuating signal generated when the size of any such defect exceeds acceptable limits.

It is therefore a principal objective of the present invention to provide a novel apparatus for on-line inspection of a moving strip of veneer whose response to the presence of through-wood defects is not affected by surface discolorations and irregularities occurring in the veneer and which is of more simplified and economical design than prior art devices heretofore utilized for this purpose.

It is a further objective of the present invention to provide, in a veneer inspection apparatus of the type described, computer means for generating an actuating signal output when the apparatus detects the presence of a throughwood defect in the traveling veneer strip whose with-grain size, or the combination of with-grain and cross-grain size, exceeds predetermined dimensional limits.

It is a principal feature of the present invention to provide an apparatus for on-line inspection of a moving strip of veneer which utilizes light transmission through the material to detect the presence and monitor the size of through-wood defects appearing therein.

It is a further principal feature of the present invention to provide a novel and improved form of scanner, for use in detecting the presence of discontinuities in a moving strip of material, which is comprised of a scanner head formed of a plurality of light-conducting optical fibers whose terminal ends are positioned adjacent the surface of the material on a side opposite an illumination source and at spaced locations along the transverse width of the material, in conjunction with a corresponding array of photoelectric transducers which are strobe interrogated in serial sequence so as to generate as an electrical output a composite waveform indicative of the light transmissibility pattern of the cross-section of material passing over the scanner head at the instance of the strobe.

The foregoing and other objectives, features and advantages of the present invention will be more readily understood upon consideration of the following detailed description of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a pictorial perspective view of an illustrative embodiment of the veneer inspection apparatus of the present invention.

FIG. 2 is an exploded pictorial view of an exemplary form of scanner head employed in the veneer inspection apparatus of the present invention.

FIG. 3 is an exploded pictorial view of the electrooptical interface assembly connecting the optical fibers of the scanner head to a corresponding array of photosensor elements in a veneer inspection apparatus of the present invention.

FIG. 3A is a sectional view of a portion of the electro-optical interface in assembled form, taken along the plane 3A—3A in FIG. 3.

FIG. 3B is a sectional view of the electrooptical interface taken along the plane 3B—3B in FIG. 3A.

FIG. 4 is a schematic diagram of an exemplary circuit means for strobe interrogation of the array of photosensor elements for generation of a pulse wavetrain representative of the instantaneous light transmissibility pattern of the veneer material under inspection by the apparatus.

FIG. 5 is a waveform diagram illustrating the output of a typical photosensor element when a through-wood opening in veneer material is sensed by it corresponding optical fiber element in the scanning head, together with a waveform diagram showing the resultant electrical signal output after it has been digitized by a threshold limiter.

FIGS. 6*a* – 6*c* are a series of diagrams illustrating the operation of the computer portion of the apparatus on a typical series of pulse trains generated by the scanner as a through-wood defect travels past the scanner head.

FIG. 7 is a block diagram of the arithmetic and logic elements comprising the computer portion of the veneer inspection apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIG. 1 depicts an illustrative embodiment of an on-line apparatus for inspecting veneer ribbon in accordance with the teachings of the present invention. A veneer strip **10**, as peeled from the log by the veneer knife, typically contains numerous through-wood defects such as knotholes **12**, splits on cracks **13**, fishtail or wane **14** and the like. The veneer ribbon is carried by a conveyor belt arrangement **15** past the inspection apparatus which comprises an illumination source **18** projecting light of relatively high intensity onto a scanner head **20** extending transversely across the width of the veneer and in proximate relation to the bottom surface thereof as it passes underneath the light source. The illumination source **18** may exemplarily be comprised of a pair of high-lumen tungsten linear-filament lamps **19** projecting a guideline light beam of high intensity onto the veneer strip as it passes underneath so that any defect extending wholly or substantially through the thickness of the material will permit a substantial amount of light radiation to pass through at that point onto the underlying scanner head **20**.

The scanner head, the details of which are depicted in FIG. 2, comprises a longitudinally-extending cylindrical rod **22** of glass or wear-resistant hard plastic extending transversely across the direction of travel of the veneer strip and bracketed on either side by a pair of plates **24** which support the roller mechanisms for the conveyor belt **15** and also serve as guide surfaces for

the veneer as it passes over the scanner head. The glass rod **22**, which is sufficiently transparent to permit light radiation to pass diametrically therethrough without substantial attenuation, is secured on a base member **26** so as to be in contact with the undersurface of the veneer strip **10** as it passes over the scanner head. The moving wood wipes the surface of the rod **22** so as to maintain it clean of dust, pitch and other foreign matter.

Spaced at regular close intervals along the length of the rod **22**, and in contact therewith at points diametrically beneath the portion of the rod surface over which veneer material passes, is a plurality of flexible, light-conducting optical fibers **27** whose respective terminal ends are secured inside the base member by a suitable fastener assembly **28**. In an exemplary arrangement the array of glass fibers might typically be spaced on one-inch centers along the width of the veneer strip so that, for monitoring veneer of nominally eight-foot width, some hundred or so individual optical fibers **27** would be contained in the array.

Any light radiation falling on the scanner head **20** as a result of the presence of through-wood defects in the veneer strip passing thereover is conducted by the optical fibers to an electro-optical interface assembly **30**, the details of which are depicted in FIGS. 3, 3A and 3B, contained, along with the remainder of the components of the system, inside a cabinet housing **29** positioned off to one side of the conveyor for easy access by personnal and energized from a suitable source of electrical potential. The electro-optical interface assembly comprises a block member **32** securing the respective ends of the array of optical fibers **27** and mating inside a keyway channel **34***a* formed inside a holder member **34**.

In forming the assembly, the array of optical fibers **27** is passed through holes **35** drilled in the block member **32** and secured inside either by a friction fit or by an adhesive so as to terminate substantially flush with the upper surface **32***a* of the block. Positioned opposite the end of each of the optical fibers **27** is a respective photosensor (or photo-electric transducer element) **38** which is positioned inside a corresponding hole **39** formed in the holder member **34**. The photosensor element, which may be of any suitable type known to the art, converts light radiation incident thereon into a corresponding electrical output whose amplitude is a function of the incident light radiation.

Interposed between the input or light-receiving end of each of the photosensors and the terminal end of its associated optical fiber conveying light from the scanner head is a shutter element **40** in the form of a thin, short strip of opaque material. The shutter, which may be positioned so as to block off a portion of the light which would otherwise be transmitted by the optical fiber to the photosensor, permits the respective outputs of the array of optical fibers and associated photosensors to be normalized so that each produces an electrical output of approximately the same amplitude under equivalent conditions of illumination at the scanner head. The positioning of the shutter strip **40** within the holder member **34**, so as to block off the requisite portion of the light transmission from the fiber end to the photosensor, may be readily accomplished with a pointed tool engaging a mating indentation **40***a* formed on the upper surface of the strip.

The electrical leads carrying the respective outputs of the photosensors **38** are connected to associated electrical components **42** carried on a printed circuit board **45** secured by fasteners **46** to the holder member to form a compact and ruggedized assembly. The array of electrical outputs derived in the electro-optical innerface assembly which are representative of the light energy incident on the scanner head is connected by a connector terminal **45***a* to the remaining "electronics" portion of the system containing the digitizing logic and arithmetic sections.

Proceeding to the electronics portion of the system and referring initially to FIG. 4, the respective outputs of the array of photosensors **38***a*. . .**38***e* is subjected to a sequential interrogation by a strobe process to effect a parallel to serial conversion of the photodector outputs. Under control of a timing clock and switching circuit (not shown but conventional), a series of enabling pulses are applied in sequence over lines y_1. . .y_5 so as to momentarily turn on the respective analog switches **50***a*. . . **50***e* connected to the individual photosensor outputs so that the resultant scanner output appearing on lead **52** is a composite waveform representing the light transmissibility pattern across the width of the veneer strip at the instant in time when the strobe interrogation is effected. After a suitable period of time, corresponding to an incremental travel of the veneer strip past the scanner head (e.g., one-tenth of an inch or so), the strobe interrogation process is repeated and a new light transmissibility pattern, corresponding to the new crosssection of material examined, is generated. The initiation of each strobe interrogation may be determined, as shown in FIG. 1 for example, by counter wheel **100** in contact with the surface of the moving strip of veneer **10** closing a contact **101** following each revolution of the wheel, or a designated portion thereof, so as to generate a signal **102** which can then be shaped into a suitable clock pulse.

The voltage vs. time waveform diagrams of FIG. 5 illustrate, respectively, a portion of the scanner output within a single strobe sequence and the same output after the digitizing thereof by a threshold detector. In the upper diagram the respective outputs of the photosensors **38***a*. . . **38***e* are shown as forming the composite scanner output **52** taken over the period of a single strobe interrogation. For the exemplary waveform shown it is assumed that, with respect to all but one of the photodetectors in the group, no significant light radiation is sensed at the respective fiber locations in the scanning head. With respect to photosensor **38***d* there is substantial light transmission due to some type of through-wood defect occurring in the wood passing over the end of its corresponding optical fiber **27** at the instant of the strobe interrogation. As to the other photomonitoring points, some slight light transmission is noted, such as by photosensor **38***b*, due to the semi-translucent character of the thin veneer material in the presence of minute irregularities not extending substantially through the wood crosssection, but no other defect similar to that indicated by photosensor **38***d* as extending substantially through the material is present at this particular instant in time.

In order to discriminate between through-wood defects which permit substantial amounts of light energy to pass through, and the minute irregularities which sometimes produce a slight amount of light transmis-

sion, a threshold level **55** is established by means of a threshold detector/limiter circuit of any suitable known design so that voltage levels below the threshold are quantified by limiting action to the same level, regardless of their input magnitude. In this manner, through the action of the threshold detector circuit, the scanner output is digitized so as to produce a serial pulse train, consisting of 1's and 0's, representing in each strobe interrogation sequence, the presence or absence respectively at scanner detection points *a. . .n* of through-wood defects along the cross-section of veneer material passing over the scanner at the instant of the strobe.

Referring now to FIGS. **6***a*–**6***c*, the series of diagrams illustrate the operation of the input to the computer in the veneer inspection system of the present invention. In FIG. **6***a* the veneer strip **10**, traveling in the direction indicated by the arrowhead **11** (i.e., from bottom to top of the figure), passes across the plane of the scanner **15**. A typical through-wood defect in the form of a split or a crack **13** extends transversely across the width of veneer somewhat skewed but substantially parallel with the grain direction. At increments of time $t_1 \ldots t_5$, representing successive initiations of the strobe interrogation sequence under control of the timing clock and corresponding to incremental advances of the strip over the scanner head, the respective scanner detection points *a. . .e*, being only a portion of the total in the scanner head array and corresponding to an adjacent set of spaced terminal ends of the optical fibers **27**, scan the wood at the instant of the strobe for the transmission of light radiation through the material from the illumination source.

FIG. **6***b* shows a series of waveform diagrams taken at the same successive intervals of time $t_1 \ldots t_5$ which represent corresponding composite (strobe-interrogated) outputs of the respective photodetector elements associated with the scanner points *a. . . e* respectively after digitizing by the threshold detector circuit. Thus, at instant of time t_1, only scanner point *a* of the array will be positioned under the void formed in the veneer strip by the crack defect **13** and thus the output of the threshold detector will produce a single pulse at position *a* in the train shown in the uppermost diagram for the time instant t_1. At the time instant t_2, both scanner points *a* and *b* will be in the void area and consequently pulses will be produced at the corresponding time locations *a* and *b* in the pulse train as indicated in the second diagram. In corresponding fashion pulse train outputs at time instants t_3, t_4, t_5 , etc. will reflect the presence or absence of voids in the strip material at the respective scanner detection points at the instant of the strobe interrogation.

The pulse train outputs of the threshold detector, representing in the form of successive waveforms the composite light transmission pattern of corresponding cross-sections of the veneer strip as it passes over the scanner head **15**, is supplied as an input to the logic portion of the computer for generating data concerning the dimensional size of the defect being monitored and determining, according to preset tolerances, when the size of the defect exceeds acceptable limits. In order to carry out this size scaling function for both cracks or splits in veneer which have relatively large with-grain size with quite narrow cross-grain dimension, and monitor as well flaws formed by knotholes and the like which have substantially larger cross-grain size, it is necessary for the logic portion of the computer to not only count the number and positional location of voids (corresponding to 1's) occurring at scanner detection points within a single pass line (i.e., strobe interrogation sequence) over the scanner head but also to compare the results of successive scanner pass lines. Accordingly, in order for the computer to properly analyze the data supplied by the output of the threshold detector circuit, it is necessary to provide means for accumulating the outputs of a plurality of successive pulse trains so as to generate information representing the size of any defect noted, both its cross-grain dimension (i.e., parallel to the direction of strip travel) as well as its with-grain dimension (transverse to strip travel). This type of accumulation can be readily effected by suitable shift register circuitry known to the art, such as for example the shift register circuit shown on page **5** of the publication by Texas Instruments entitled "TTL Integrated Circuits. Counters and Shifts Register", Bulletin CA–**102**.

The accumulator in the logic portion of the computer accumulates the results of successive outputs of the threshold detector circuit of FIG. **6***b* so as to produce in successive intervals of time $t_1 \ldots t_5$ composite waveforms shown in the diagram of FIG. **6***c*. Thus, considering for example the accumulator contents at time instant t_3, it will be noted that the pulses or bits produced in the immediate time interval (t_3) as well as the two preceding intervals (t_1 and t_2) are accumulated to produce a composite pulse train having pulses at scanner detection points *a*, *b*, and *c*. Proceeding onward to the fifth time interval diagram (t_5), the contents of the accumulator which has now added the results of the immediate as well as those of the preceding four time intervals, indicates a pulse or bit in all five of the positions *a. . .e* corresponding to scanner detection points, even though at time interval t_5 only a single pulse is produced, at location *e*, due to the presence of a void at that particular scanner detection point. In this fashion the accumulation of the results of a multiplicity of successive pulse train waveforms, each indicating the presence and relative lateral position of voids appearing in the strip material as detected by closely-spaced monitoring points situated along the length of the strip as it travels over the scanner, produces digital information for processing in the logic portion of the computer which represents the with-grain dimension of such defects.

Referring now to FIG. **7**, which is a block diagram of the computer portion of the system, it will be observed that the logic units can be divided into two parts, one, designated as **60**, for monitoring the size of cracks or splits in the wood which, as indicated earlier, have relatively large with-grain dimension, and the other, designated as **70**, for monitoring the size of laws such as knotholes and the like which have relatively large cross-grain size. With regard to the former type of wood defect, the crack detection logic **60** operates on the data provided by the output of the threshold detector circuit **54** to determine the with-grain dimension of each crack or split appearing in the strip and compares the reading with a preset limit. To this end, the output of the threshold detector **54** is supplied to the accumu-

lator **62** previously described as being essentially a shift register for accumulating the contents of a plurality of successive scans (pulse trains) made by the inspection apparatus. A reset element **64**, connected to receive inputs from both the threshold detector and the accumulator, is used to clear the latter depending on the result of the most recent scans and the contents of the accumulator at that time. Thus, for example, the reset could operate to clear the accumulator contents after the receipt of a predetermined number of scans unless the subsequent scans contain input information which increase the contents of the accumulator (i.e., the number of stored pulses) thereby indicating that the crack defect under observation is either skewed with respect to the grain or growing in size as the strip traverses past the scanner head.

The output of the accumulator, which itself is a pulse train indicating, as depicted in FIG. **6***c*, the number and position of voids (C_D's) noted at scanner detection points over an accumulation of successive scans, is supplied to a counter **66** which sums the total of such voids (ΣC_D) to generate an output representing the lateral or with-grain size of the crack or split producing such voids in the strip. When the crack exceeds a certain with-grain size, as determined by comparison in comparator **68** of the output (ΣC_D) of the counter **66** and a preset crack limit (C_L), the comparator element generates an output signal over line **69** which can be used as an actuating signal to initiate the operation of a clipper knife.

The second portion of the computer system, the flaw detection logic **70**, simultaneously monitors both the with-grain and cross-grain size of any defect noted in order to detect the presence of any open knothole or the like whose area exceeds a certain size. A description of the design and operation of this portion of the computer system is provided in the aforementioned U.S. Pat. No. 3,560,096 whose disclosure is herein incorporated by reference.

In similar fashion to the crack detector logic **60**, the flaw detection logic accumulates or stores the results of successive scans while also examining the results of each scan line individually. Again, as an input to the logic, the threshold detector **54** supplies the digitized pulse train representing the number and position of voids detected by the scanner at the instant of the strobe interrogation of the photosensor elements associated with each scanner detection point. A counter **72** counts the number of pulses or bits detected at contiguous scanner detection points and supplies this total (ΣWG_D) to a comparator **74** which in turn compares the total of with-grain voids detected with a preset with-grain limit (WG_L) to generate an output on line **75** whenever the number of voids detected on a single scan line exceed the preset limit. (Typically the with-grain WG_L would be smaller than the crack limit C_L set in the crack detection logic so as to have the flaw detection logic respond to the presence of defects in the veneer strip whose lateral or with-grain dimension is not large enough to be classified as an unacceptable crack.)

The output of the with-grain comparator **74** is supplied to a second counter **76** which is designated as a cross-grain counter since it functions to ascertain the cross-grain size of any defect noted, i.e., its size in the direction longitudinal of the strip. The counter summation (ΣXG_D), derived from tallying the number of successive scan lines containing with-grain defects of excessive size, is supplied to a second comparator **78** which compares this reading to a preset cross-grain limit (WG_L) so as to generate an output signal when a flaw of excessive size is detected.

The terms and expressions which have been employed in the foregoing abstract and specification are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described, or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

What is claimed is:

1. In a scanner, for use in inspecting a moving strip of planar material and responsive to incident light energy transmitted through openings or other defects appearing in said material, comprising an array of flexible, longitudinally-extending light-conducting optical fibers whose first terminal ends are respectively situated at spaced positions proximate to said strip and extending transversely of the direction of strip movement, and whose second terminal ends are optically coupled in one-to-one relationship to a corresponding array of photoelectric transducer elements for converting said incident light energy into an electrical output, the improvement wherein the respective second terminal ends of the array of optical fibers are each secured inside corresponding bore openings formed in a block member which is adapted to mate with a keyway channel provided in a holder member, said holder member containing the array of corresponding photoelectric transducer elements, the assembly of said block and holder members serving to hold and maintain said first terminal ends of said optical fiber array in positional alignment with their respective photoelectric transducer elements.

2. A scanner according to claim **1** further comprising adjustable shutter means formed of longitudinally-movable thin, short strips of opaque material situated on one of said members between said respective second terminal ends of said optical fibers and their associated photoelectric transducer elements contained on said holder member, whereby the adjustment of the position of a respective strip blocks off a selectable portion of the light energy transmitted by the optical fiber associated therewith in order thereby to provide means for normalizing the responses of said photoelectric transducer elements to a uniform level.

3. Flaw detection apparatus for inspecting a moving strip of planar material comprising:

a. an illumination source on one side of said strip projecting light thereon,

b. a scanner situated on the other side of said strip and producing an electrical output in response to light transmitted through any openings appearing in the material passing between said illumination source and said scanner,

c. pulse converter means for converting said electrical output of said scanner into a series of pulse train waveforms respectively representative of the instantaneous light transmission pattern across the width of the material taken at spaced locations along the length of said strip,

d. accumulator means for accumulating the results of a predetermined number of successive pulse trains corresponding to successive scans of said material as it passes between said illumination source and said scanner,

e. first counter means for totaling the resultant pulses collected in said accumulator means,

f. means for comparing the pulse total in said first counter with a first predetermined value so as to provide an output signal from said apparatus when said value is exceeded, said output signal denoting the presence of an opening in said strip whose major dimension exceeds a tolerance limit,

g. second counter means for totaling the number of pulses in each of said pulse trains produced by said pulse converter means,

h. means for comparing the total obtained by said second counter means with a second predetermined value so as to derive a second signal when said second value is exceeded, and

i. third counter means for counting the number of times said second signal is produced and generating a third signal when the count in said third counter exceeds a third predetermined value, said third signal serving as an additional output signal from said apparatus denoting the presence of an opening in said material whose size exceeds a set of predetermined tolerance limits on both its transverse and longitudinal dimensions.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,694,658 Dated September 26, 1972

Inventor(s) Gerald L. Watson and Don Latshaw

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 4,	Line 45	Change "on" to --or--.
Col. 6,	Line 16	Change "photodector" to --photodetector--.
Col. 6,	Line 32	Change "crosssection" to --cross-section--.
Col. 6,	Line 61	Change "crosssection" to --cross-section--.
Col. 8,	Line 59	Change "laws" to --flaws--.

Signed and sealed this 13th day of February 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

145

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334