Oct. 1, 1968 H. SCHÄFER 3,403,782

SHEET MATERIAL CUTTING AND SORTING APPARATUS

Filed Nov. 12, 1964 2 Sheets-Sheet 1

Fig.1

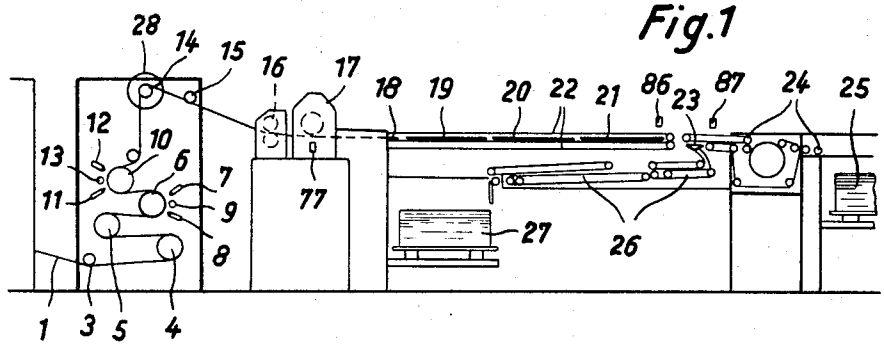


Fig.3

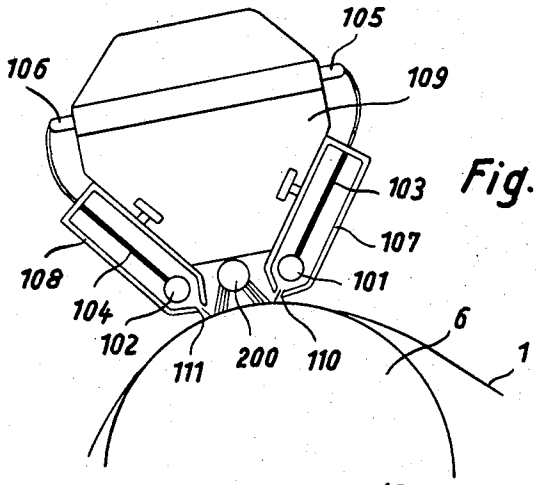
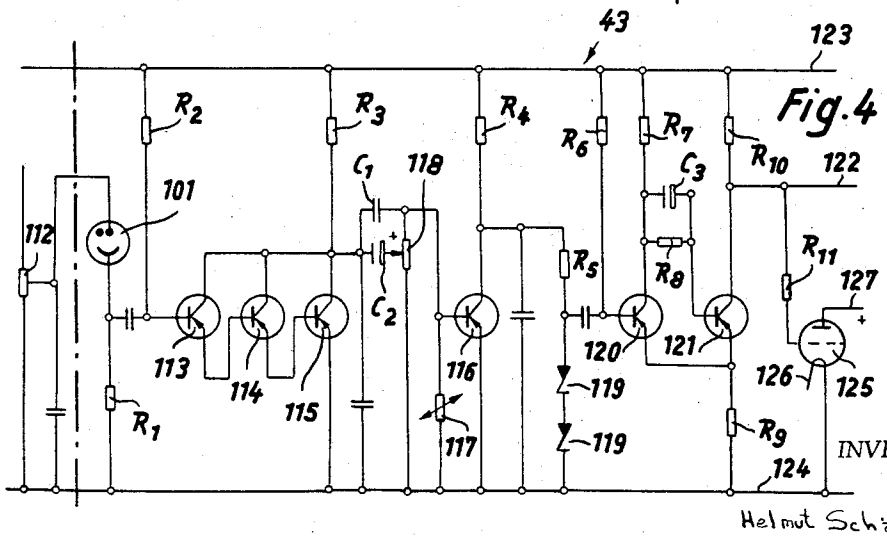


Fig.4



INVENTOR

Helmut Schäfer

BY Sparrow and Sparrow

ATTORNEYS

Oct. 1, 1968 H. SCHÄFER 3,403,782

SHEET MATERIAL CUTTING AND SORTING APPARATUS

Filed Nov. 12, 1964 2 Sheets-Sheet 2

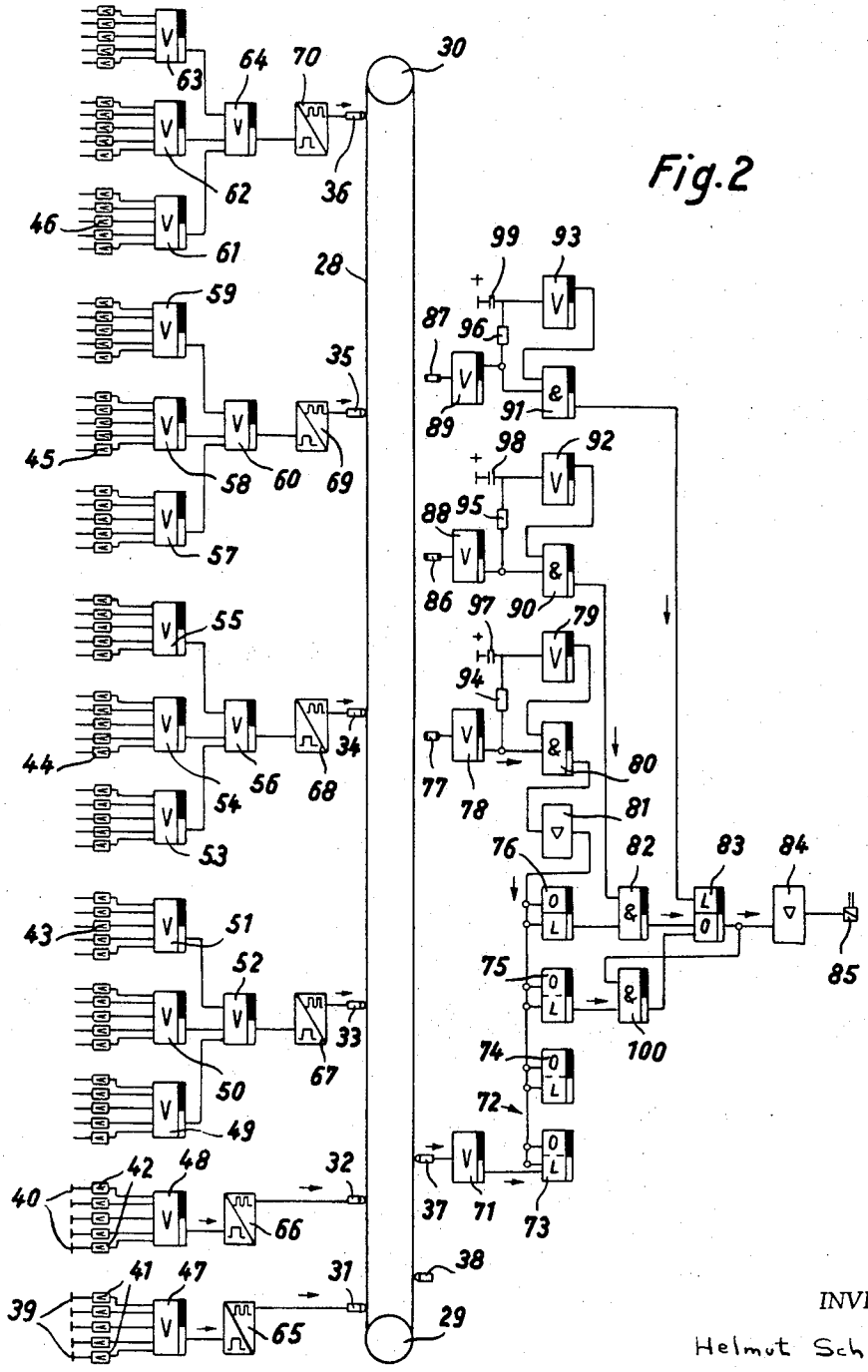


Fig.2

INVENTOR
Helmut Schäfer

BY
Sparrow and Sparrow
ATTORNEYS

United States Patent Office 3,403,782 Patented Oct. 1, 1968

3,403,782

SHEET MATERIAL CUTTING AND SORTING APPARATUS

Helmut Schäfer, Neuffen, Germany, assignor to Hans Biel, Neuffen, Wurttemberg, Germany

Filed Nov. 12, 1964, Ser. No. 410,514
Claims priority, application Germany, Nov. 14, 1963, B 74,255
4 Claims. (Cl. 209—75)

The invention relates to sheet material cutting and sorting apparatus in which a web of material, such as paper, may be scanned at several scanning points for faults and then cut transversely by a cross-cutter into sheets whereafter the good and faulty sheets are sorted by a separator into separate stacks of good and faulty sheets.

As is already known local thickening of the web and holes in the web may be detected by mechanically scanning the web or surface faults may be detected by optically scanning the web. In a known cutting and sorting apparatus in which the web is scanned photoelectrically, the defective sheets are marked by punching and these markings are used for setting the separator. However, this method is suitable only for web velocities of up to about 40 m./min. because with faster speeds, punching is no longer possible. In addition, owing to the punch mark, faulty sheets can no longer be used for other purposes where the quality requirements are less stringent.

Optical scanning uses a method in which the beam of a point source of light is directed on to the web through a half-silvered mirror and other optical devices.

A mirror drum revolving at high speed causes a light spot to periodically pass across the surface to be scanned at high speed in the direction normal to the movement of the web. From the surface of the web the light passes to a photoelectric receiver which gives rise to electric impulses when surface faults are detected and these impulses are used for setting the separator. Although this method can be used for high web velocities it is very expensive owing to the optical precision elements.

It is also known to continuously scan the web by photoelectric means and to store the fault signals which are transmitted discontinuously to the separator, e.g., by means of two pin drums. However, it is also known to use magnetic tapes or magnetic drums for the continuous recording and storing of signals. Again it is known for the fault signals produced at different scanning points to be recorded by magnetic heads associated with these scanning points on different tracks of a magnetic tape connected to a roller drive for advancing the web and to be passed through repeater heads to a system of relays where the signals are stored and released at the instant of the next cut by a cam switch, synchronized with the cross-cutter, to a cam-operated signal control driven by the conveyor drive. The signals are stored in this control until they are applied to the separator for a time equal to that required by the leading edge of a sheet to reach the separator, so that the magnetizing and repeater heads must be so arranged that the distance between one magnetizing head and the associated repeated head, with regard to the running time is equal to the distance between the associated scanning member and the fixed cross-cutter blade. In this known device, however, the advantages produced by the temporary storage on the magnetic tape are practically destroyed by the mechanically expensive and by no means foolproof relay system, which is moreover difficult to repair.

Sheet material cutting and sorting apparatus constructed in accordance with the invention comprises a cross-cutter for transversely cutting a web of material, such as paper, into sheets, means for passing the web through a plurality of scanning points and then to the

cross-cutter, fault detecting means at each scanning point for detecting faults in the web, a separator for separating faulty sheets from good sheets, means for conveying the sheets from the cross-cutter to the separator, a magnetic storage medium movable in synchronism with said web, passing means, a magnetizing head associated with each scanning point for recording a fault signal on said storage medium responsively to the detection of a fault by said fault detecting means at the associated scanning point, a read-out head for reading out fault signals from the storage medium, the distance of each magnetizing head (measured along the recording medium) from the read-out head corresponding to the distance of the associated scanning point (measured along the path of the web) from the cross-cutter, and a shift register connected between the read-out head and the separator, said register having storage locations for storing the fault signals until required and operable to shift fault signals stored therein from one location to the next in synchronism with operation of the cross-cutter, the number of storage locations in the shift register corresponding to the number of cut sheets which in operation, are present between the cross-cutter and the separator, whereby the separator is actuated to divert to a "reject" stack those sheets upon which a fault is detected.

It has been found that such apparatus may be used for web velocities of 400 m./min. All the electrically components may be chosen to be commercially available and so easily exchangeable.

For optically scanning the web, the light of an elongate incandescent light source, such as a D.C. operated fluorescent tube, may be directed on to one side of the web from which it is reflected on to two spaced rows of light sensitive cells, of which each row corresponds to the scanning point, the cells of one row being offset relatively to those of the other row so that the web can be scanned across its full width. Each light sensitive cell is associated with an amplifier which, in the event of a fault signal, passes this signal through one or more network stages to its associated magnetizing head. By means of this division of the optical scanning of one side of the web into two rows, the whole width of the web can be completely scanned at minimum expenditure.

The invention will be further described by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic elevation of a device for separating faulty sheets constructed in accordance with the invention and containing novel, specially designed amplifiers for mechanical and optical systems;

FIG. 2 is a circuit diagram of the arrangement according to FIG. 1;

FIG. 3 is a view of the optical device for scanning one side of the web; and

FIG. 4 is a circuit diagram of a novel amplifier for the optical fault signals.

Referring to FIG. 1, a paper web **1** is fed from a reel (not shown) and may pass through a number of printing rollers. The web **1** then passes under a guide roller **3** to a first scanning point **4**, whereat it is so reversed that the underside of the paper may be examined at a second scanning point **5**. The web is mechanically scanned at the scanning points **4** and **5**. The web passes over a dark roller **6** associated with two optical scanning points **7** and **8** with a light source **9** for the upper side of the web. Next, the web is again reversed and passes over a second dark roller **10** having similar scanning points **11** and **12** and a light source **13** for the underside of the web. By means of further rollers **14**, **15** and **16**, the web is then guided to a cross-cutter by which it is transversely cut into sheets. The sheets, of which four are indicated by the reference numerals **18**, **19**, **20**, **21**, are transported between belts **22**

to a separator 23. Here, they are deposited in accordance with the position of the separator by means of systems 24 of rollers and belts on to a "good" stack 25 or through other systems 26 of rollers and belts on to a "reject" stack 27.

A magnetizing storage medium 27 runs together with the material web and without separate drive, the effective length of the medium 28 corresponding to the distance between the first scanning point 4 and a common read-out point for all fault signals. The fault signals are applied to the storage medium 28 through each scanning point at a position corresponding to its relative position. The storage medium in the embodiment shown (FIG. 2) is an endless magnetic tape 28 running over rollers 29 and 30. It is also possible to use a magnetic drum.

The scanning points 3, 4, 7, 8, 11 and 12, are associated with magnetizing heads 31 to 36 respectively, whose positions along the magnetic tape correspond to the distances between the corresponding scanning points and a read-out head 37. The fault signals are erased in advance of the roller 29 by an eraser head 38.

The fault signals are supplied to the magnetic tape directly and without the use of an oscillator, because the magnetizing heads operate in the saturation range. For this reason, it is possible to record all fault signals on one track of the tape so that a single amplifier 71 can be connected to the read-out head 37 and not, as with a known apparatus, an amplifier which must have a separate preamplification input channel for each read-out head. This simple arrangement need only be rejected if the scanning points are so close together that the corresponding magnetizing heads cannot be placed side by side for lack of space. In this case the magnettizing heads are offset relative to one another, the recordings are made on spaced tracks and several read-out heads are required, or a single read-out head may be used if it is sufficiently wide.

Since the paper web can be rather wide it is scanned by several scanning elements spaced across the width of the web. The mechanical scanning is effected by so-called wipers, shown diagrammatically at 39 and 40 in FIG. 2. As hereinafter described the optical scanning is effected by photoelectric cells. Each scanning element is connected to an amplifier. As shown in FIG. 2, five amplifiers 41 serve the wipers for scanning one side and five amplifiers 42, those for scanning the other side of the web whilst amplifiers 43 and 44 are for the photoelectric cells for optically scanning the first and the amplifiers 45 and 46 for the photoelectric cells for optically scanning the second side of the web. All amplifiers of one scanning point are connected to an OR gate which issues in turn in the case of a fault signal through one amplifier, i.e., in the presence of a fault at any point over the web width, a signal to the associated magnetizing heads 31 to 36. Since suitable commercially available OR gates have five inputs and there are five wipers for scanning the web at each scanning point 4 or 5 one single OR gate 47 or 48 is sufficient for one mechanical scanning point 4 or 5. For the optical scanning points more elements (fifteen in the illustrated embodiment) are required, and accordingly each of three OR gates 49, 50, 51 or 53, 54, 55 or 57, 58, 59 or 61, 62, 63 is connected in series with a fourth OR gate 52 or 56 or 60 or 64, respectively. Impulse doublers 65 to 70, supplying one impulse for each flank of the fault impulses, are arranged between the OR gates 47, 48, 52, 56, 60 and 64, and the magnetizing heads 31 to 36, respectively. Thus, if the web should be cut across a fault, the separate pulses obtained at the beginning and the end of the fault enable the faults on both successive sheets produced by the cross-cutter 17 to be registered.

The read-out head 37 (FIG. 2) is located immediately in advance of the cross-cutter 17 (FIG. 1). If the read-out head 37 detects a fault signal, it supplies this through a magnetic tape amplifier 71 into a shift register 72 comprising storage locations 73 to 76, each of which is a commercially available impulse memory unit. The number of locations in the shift register corresponds to the number of sheets between the read-out head 37 and the separator 23 (FIG. 1). The shift register is controlled in synchronism with the cross-cutter. To this end, the cross-cutter 17 contains a photoelectric cell 77 (FIGS. 1 and 2) which supplies an impulse at every cut through an OR gate 78, acting as an amplifier, both directly and through a flip-flop 79 to an AND gate 80. The impulse passes through an intermediate amplifier 81 to the shift register 72. Thus, in the sheet positions shown in FIG. 1, fault signals for the sheet 21 may be in the location 76, for the sheet 20 in the location 75, for the sheet 19 in location 74, and for the sheet 18 in the location 73. The last shift register location 76 is connected to bistable flip-flop stages, comprising an AND gate 82, a static memory 83, and an amplifier 84 with an arrangement 85 for setting the separator.

In front of the separator 23 (FIG. 1) there is a photoelectric cell 86 which, when a sheet arrives (e.g., sheet 21) passes a "query" impulse to the AND gate 82 of the blocking memory stage, connected to the last shift register location 76. If the last shift register location contains a fault signal, this is passed on by the AND gate 82 and the separator is so adjusted that the sheet is deposited on to the "reject" stack (FIG. 1).

Beyond the separator 23 there is a further photoelectric cell 87 in the path of the faulty sheet, which passes a resetting impulse for the separator to the storage stage 83 when a sheet runs to the "reject" stack.

The circuits for the photoelectric cells 86 and 87 correspond largely to that for the photoelectric cell 77. They contain gates 88, 89, AND gates 90, 91 and flip-flops 92, 93. In all three circuits, the flip-flops 79, 92, 93 are connected through a resistor of about 5 kilohm 94, 95, 96 to the gates 78, 88, 89 and through a capacitor 97, 98, 99 to a positive potential. The output of the gates 78, 88, 89 applied to the AND gates 80, 90, 91, and the outputs of the flip-flops 79, 92, 93, connected to these AND gates depends on the method used, i.e., whether the front or rear edge of each sheet is used to provide the "query" and "setting" impulses, and on the position of the photoelectric cells.

In FIG. 2, the output of the gate 78 is connected to the AND gate 80. Operation is effected with "constant trailing edge" of the sheets, and the photoelectric cell 77 reacts on brightness; if "constant gap" between the sheets were used the "black showing" output of the stage 78 would be connected to the AND gate 80 and the cell would react correspondingly to darkening. Similarly, in FIG. 2, the photoelectric cell 86 reacts to the transition from dark to light, i.e., to the trailing edge of the sheet and the photoelectric cell 87 to the transistion from light to dark, i.e., to the leading edge of the sheet. Modifications with changes from constant trailing edge to constant gap and vice-versa are easily effected.

In the circuit of FIG. 2, the penultimate storage location 75 of the shift register 72 is connected to an AND gate 100 whose other input is obtained from the static memory 83 and whose output is applied to the static memory 83. This AND gate acts with regard to the resetting impulse for the separator in the same way as the AND gate 82 for the query impulse, i.e., before resetting the separator, the penultimate storage location is read for the presence of a fault signal. If there is such a fault signal, the separator is not reset and remains at "reject" so that it is not unnecessarily operated.

FIG. 3 shows diagrammatically a device for optically scanning the side of the web. Also here, only commercially available components have been used. The light source is a fluorescent tube 200 operated with D.C. and having a relaxation frequency higher by 15 to 25 kc./s. than the fault frequency of 1 to 5 kc./s. Within the region of the roller 6 the light of the fluorescent tube is reflected from the web to two rows of photoelectric cells 101, 102,

the cells in one row being offset relative to those of the other row so as to scan the entire width of the web. Conveniently, the roller **6** is a dark rubber roller in the same way as the roller **10**, so that the background of the web does not affect the reflection of the light. Each photoelectric cell **101, 102** is associated with an amplifier which can have the form of a printed circuit **103. 104**. The amplifiers pass the fault signal on the one hand to the OR gates **49** to **55**, and on the other hand, to a voltage indicator **105** or **106**, which indicates the occurrence of a fault signal.

The fluorescent tube **200**, the photoelectric cells **101** and **102** (fifteen of each in number, see FIG. 2), the amplifiers in the form of printed circuits **103, 104** (again fifteen of each) and the voltage indicators **105, 106** (again fifteen of each) are installed in one unit. To this end, the photoelectric cells and the associated amplifiers are mounted in housings **107, 108**, located in turn with the voltage indicators **105, 106**, in a frame **109** extending across the web **1**. The light passes through slots **110, 111**, in the housings **107, 108**, to the photoelectric cells **101, 102**. Since the slots **110, 111** are very narrow the photoelectric cells **101, 102** receive only little light. The input for the associated amplifier, e.g., **43** in FIG. 4, is very high ohmic, so that a lead with very low capacitance to earth between the photoelectric cell and amplifier would lead to a short circuit. For this reason, the photoelectric cells and their amplifiers are located very near each other and only very high ohmic components are connected in series.

The amplifier **43** for the photoelectric cell **101** is shown in FIG. 4. All photoelectric cells for one side of the web (in this embodiment thirty photoelectric cells) are connected through a resistor **112** to a common voltage source of −80 v. The high ohmic input signal (R_2=20 megohms) supplied by the photoelectric cell **102**, connected to earth through a resistor R_1=5 megohms, is amplified by three silicon transistors **113, 114, 115**, located at the working point. The output resistance of the last amplifier stage is now low-ohmic (R_3=15 kilohms), but the signal is too weak. It is again amplified by a germanium transistor **116**, operating beyond the working characteristic. In front of the germanium transistor **116**, whose base is connected through a resistor **117** with a negative temperature coefficient (10 kilohms) in order to compensate for the temperature instability, there are two parallel connected capacitors C_1=0.1 μf. and C_2=0.25 μf. The capacitor C_2 serves for adjusting the signal level relative to a potentiometer **118** (50 kilohms), whilst the capacitor C_1 which passes basic signals, serves to ensure that major faults are registered in the event of misadjustment of the potentiometer **118**. The germamium transistor **116** is coupled through Zener diodes **119** so that it passes only signals above a certain threshold value. These signals pass to a germanium transistor **120** and a silicon transistor **121**, forming a trigger stage and producing an output signal of defined level which passes through a lead **122** to the appropriate OR gate, e.g., **49**. The illustrated capacitors, not specifically mentioned have capacitances of 0.1 μf. The capacitor C_3 is an electrolytic capacitor of 10 μf. The resistors R_4, R_5, R_6 have values of 15 kilohms, the resistor R_7 is about 10 kilohms, R_8 is 50 kilohms R_9 is 100 ohms and R_{10} is 2 kilohms. The lead **123** is at −24 v. and the lead **124** is earthed.

The voltage indicator is a hot cathode tube **125** whose grid is connected through a resistor R_{11} (100 kilohms) to the lead **122** and whose cathode is connected to earth and at **126** to a +1 v. The anode is connected at **127** to +50 v.

For the mechanical scanning, substantially the same amplifiers can be used. However, here the transistor **113** is omitted and the resistor R_2 has a value of 10 megohms.

The electronic equipment of the apparatus is inexpensive, operates quickly and requires only commercially available components so that repairs can be effected without difficulties. It is suitable for detecting any practically important faults (thicker portions, spots, and the like). Since the faulty sheets need not be marked mechanically, such as by punching they may be used where the requirements made of the material, such as paper, are not particularly high.

I claim:

1. Apparatus for sorting faulty sheets comprising a cross cutter for cutting a web of material, such as paper, into sheets, fault detecting means, said web passing through said detecting means, a separator for said faulty sheets, control means for said separator, stacks for both said faulty and for good sheets, at least one scanning station in said detecting means, said scanning station generating a fault signal upon detecting of a fault in said web, an impulse doubler, said fault signal being imposed upon said doubler, said doubler converting said fault signal into impulses indicating both the beginning and the end of said fault signal, intermediate storage means, said impulses being subsequently stored in consecutive order in said storage means, and synchronizing means for imposing the individual impulses of said control means onto said separator when a sheet having either said beginning or said end fault arrives at said separator.

2. In apparatus having scanning stations for scanning of a web of material, such as paper, for faults, a cross cutter for subsequently transversely cutting said web into sheets, a separator for separating the good and the faulty sheets from one another and stacks for both said good and said faulty sheets: means for passing the web through a plurality of said scanning stations and then to said cross-cutter, fault detecting means at each of said scanning stations for detecting faults in said web, means for conveying said cut sheets from said cross-cutter to said separator, a magnetic storage medium, means for moving said storage medium in synchronism with said web passing means, a plurality of recording heads, one of each associated with each one of said scanning stations for recording fault signals on said storage medium responsive to the detection of a fault by any one of said fault detecting means at said associated scanning station, a read-out head for reading out fault signals from said storage medium, the distance of each of said recording heads, taken along said recording medium, from said read-out head corresponding to the distance of said associated scanning station, taken along the path of said web, from said cross-cutter, a shift register connected between said read-out head and said separator, said register having storage locations for storing said fault signals until required, the number of storage locations in said shift register corresponding to the maximum possible number of cut sheet lengths between said cross-cutter and said separator, and means for effecting shifting operations in said register in synchronism with operation of said cross-cutter to transfer fault signals from one storage location to the next, actuating said separator to divert sheets found faulty to said stack for faulty sheets, an impulse doubler, said doubler associated with at least one recording head, said doubler converting said fault signals, recorded by said recording head, prior to being recorded on said magnetic storage medium, into impulses indicating both the beginning and the end of said fault signal.

3. In apparatus having scanning stations for scanning of a web of material, such as paper, for faults, a cross-cutter for subsequently transversely cutting said web into sheets, a separator for separating the good and the faulty sheets from one another and stacks for both said good and said faulty sheets; means for passing the web through a plurality of said scanning stations and then to said cross-cutter, said web passing means including at least one dark roller for supporting said web at said scanning stations, said scanning stations having optical scanning elements, fault detecting means at each of said scanning stations for detecting faults in said web, means for conveying said cut sheets from said cross-cutter to said separator, a mag-

netic storage medium, means for moving said storage medium in synchronism with said web passing means, recording heads associated with the individual scanning stations for recording a fault signal on said storage medium responsive to the detection of a fault by said fault detecting means at said associated scanning station, a read-out head for reading out fault signals from said storage medium, the distances of said recording heads, taken along said recording medium, from said read-out head corresponding to the distances of said associated scanning stations, taken along the path of said web, from said cross-cutter, means for setting said separator, a shift register having a series of storage locations for storing fault signals, said locations corresponding in number to the maximum possible number of cut sheet lengths between said cross-cutter and said separator, the first of said locations being connected to said read-out head to receive fault signals therefrom, means for reading out fault signals from the last of said locations and applying them to said separator setting means, and means for effecting shifting operations in said register in synchronism with operation of said cross-cutter to transfer fault signals from one storage location to the next, actuating said separator to divert sheets found faulty to said stack for faulty sheets.

4. In apparatus having scanning stations for scanning of a web of material, such as paper, for faults, a cross-cutter for subsequently transversely cutting said web into sheets, a separator for separating the good and the faulty sheets from one another and stacks for both said good and said faulty sheets; means for passing the web through a plurality of said scanning stations and then to said cross-cutter, fault detecting means at each of said scanning stations for detecting faults in said web, means for conveying said cut sheets from said cross-cutter to said separator, a magnetic storage medium, means for moving said storage medium in synchronism with said web passing means, recording heads associated with the individual scanning stations for recording a fault signal on said storage medium responsive to the detection of a fault by said fault detecting means at said associated scanning station, a read-out head for reading out fault signals from said storage medium, the distances of said recording heads, taken along said recording medium, from said read-out head corresponding to the distances of said associated scanning stations, taken along the path of said web, from said cross-cutter, means for setting said separator, a shift register having a series of storage locations for storing fault signals, said locations corresponding in number to the maximum possible number of cut sheet lengths between said cross-cutter and said separator, the first of said locations being connected to said read-out head to receive fault signals therefrom, means for reading out fault signals from the last of said locations and applying them to said separator setting means, and means for effecting shifting operations in said register in synchronism with operation of said cross-cutter to transfer fault signals from one storage location to the next, actuating said separator to divert sheets found faulty to said stack for faulty sheets, at least two of said scanning stations adapted for scanning of the same kind of faults, said scanning stations arranged on both sides of said web of material for scanning of faults on either side of said web.

References Cited

UNITED STATES PATENTS

2,637,810	5/1953	Moerman	328—38 X
2,950,640	8/1960	Camp	209—111.7 X
2,999,590	9/1961	Gerhardt	209—82
3,070,227	12/1962	Larew	209—75

M. HENSON WOOD, JR., *Primary Examiner.*

R. A. SCHACHER, *Assistant Examiner.*