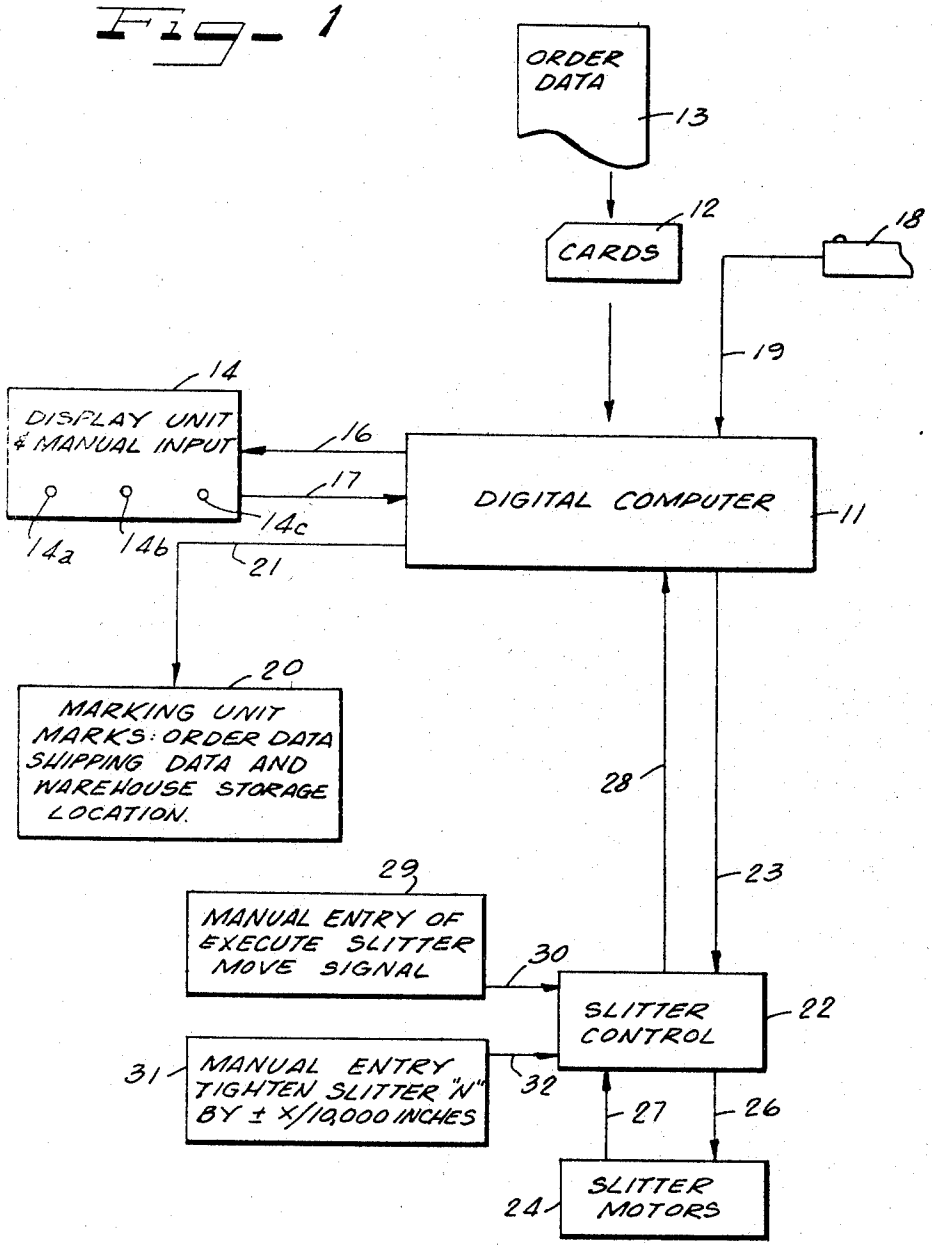
Jan. 6, 1970 M. A. KEYES ET AL 3,488,479

AUTOMATED SLITTING SYSTEM

Filed Jan. 5, 1966 4 Sheets-Sheet 1

Fig. 1



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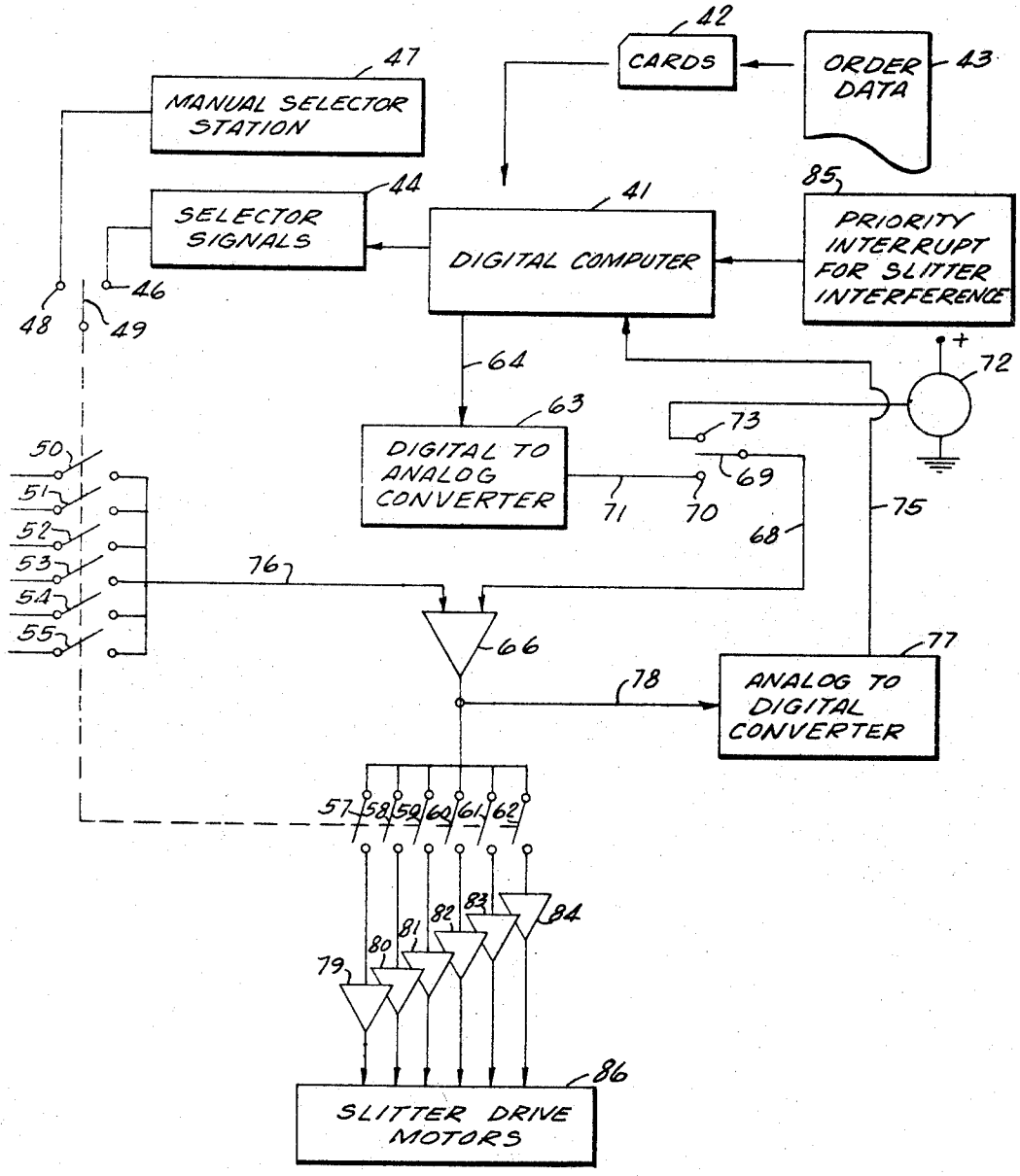
AUTOMATED SLITTING SYSTEM

Filed Jan. 5, 1966 4 Sheets-Sheet 2

Fig. 2



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AUTOMATED SLITTING SYSTEM

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Fig. 3

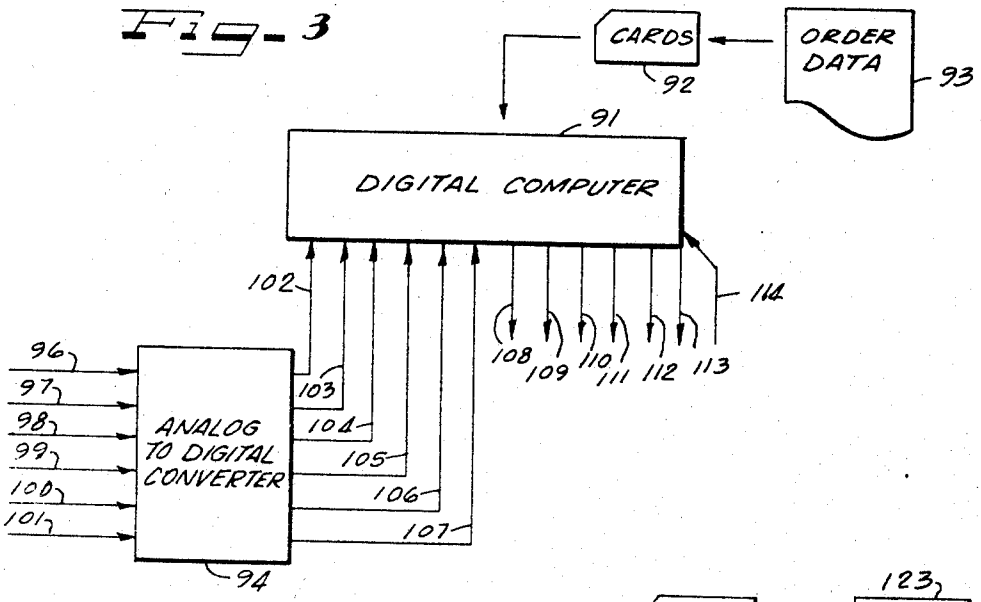


Fig. 4

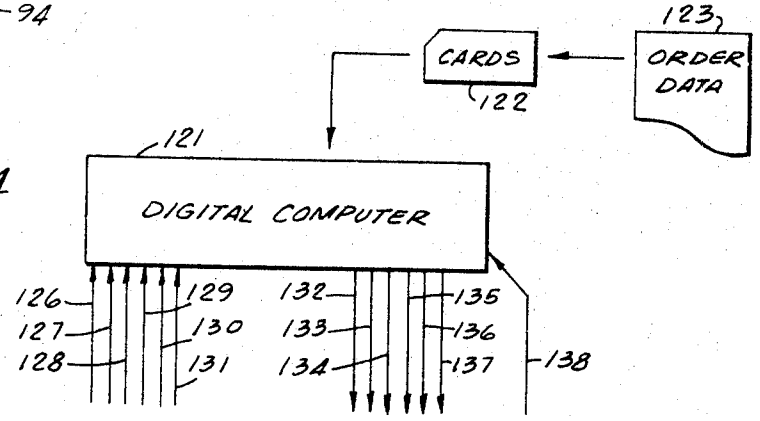
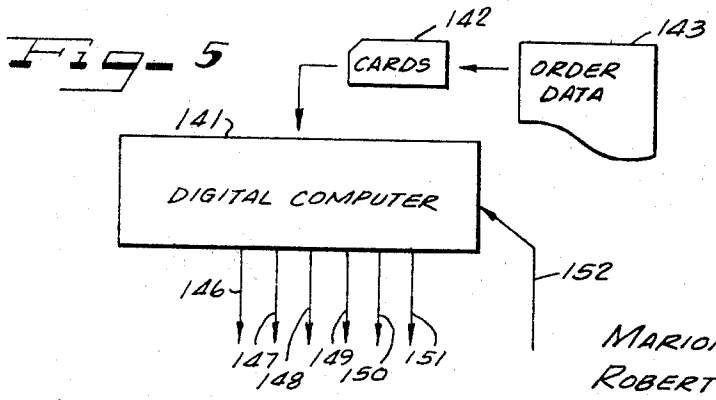


Fig. 5



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AUTOMATED SLITTING SYSTEM

Filed Jan. [illegible], 1966 4 Sheets-Sheet 4

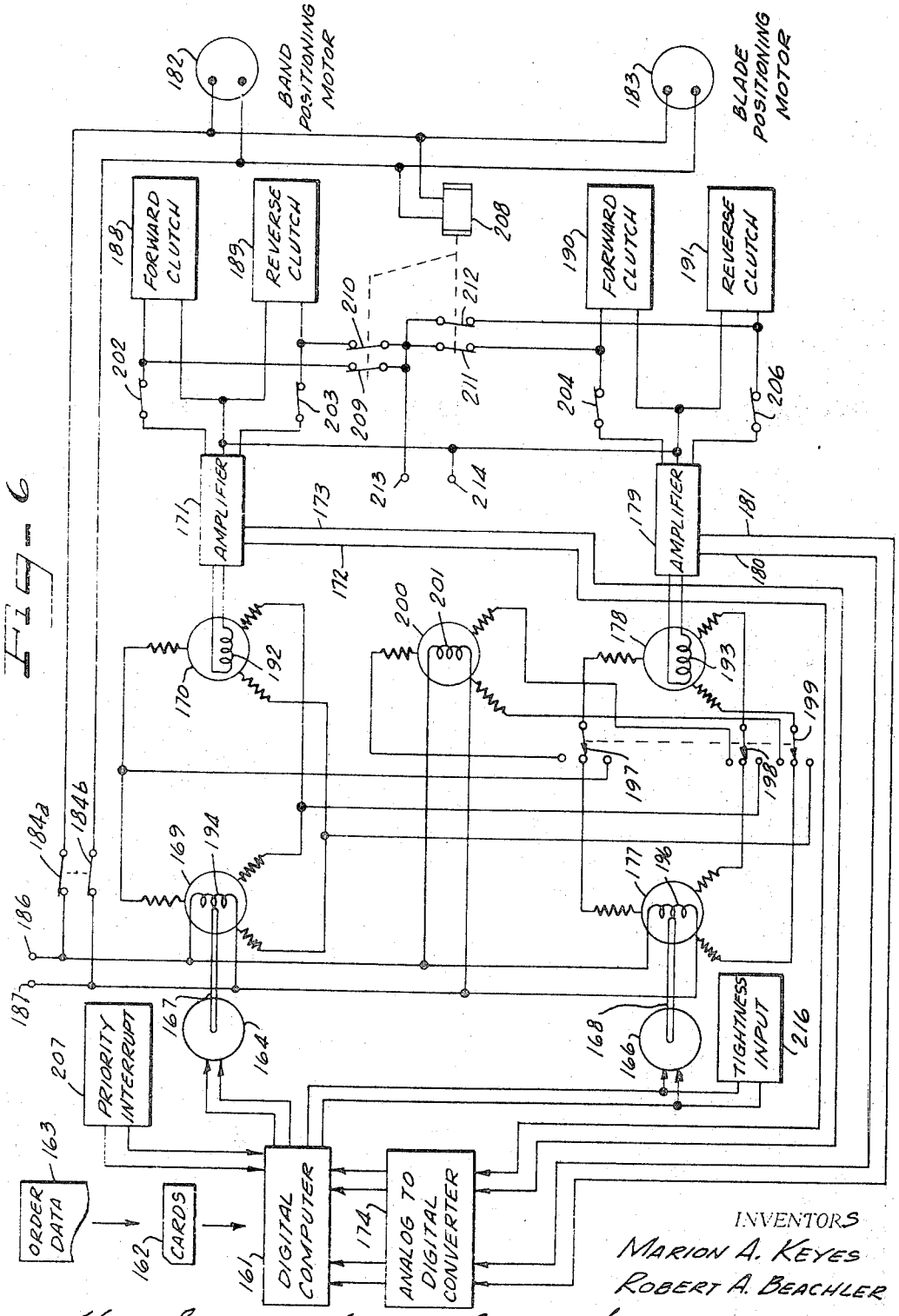

Fig. 6

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United States Patent Office 3,488,479 Patented Jan. 6, 1970

3,488,479

AUTOMATED SLITTING SYSTEM

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Int. Cl. G06f 15/46; G06g 7/48
U.S. Cl. 235—151.1 9 Claims

ABSTRACT OF THE DISCLOSURE

A slitter system for sheet materials for dividing a web of paper fed from a supply roll into two or more narrower webs so as to provide minimum waste of paper. A computer compares the orders with the width of the master roll and determines the optimum positioning of slitter motors so as to sufficiently utilize the paper.

This invention relates generally to a slitter system for sheet materials and more particularly to a system wherein a web of paper or the like fed from a supply roll is separated into two or more narrower webs which may then be wound on separate rolls. More specifically, the present invention is related to an automatic slitting system which performs many of the functions heretofore accomplished manually.

Winding mechanisms which are employed for winding, slitting and rewinding a web material operate in a discrete fashion; that is, they generally accept only one large roll at a particular time which is then unwound and slit into one or more separate smaller rolls. The actual slitting process is accomplished by the shearing action of a plurality of opposed rotating blades. A different set-up is required of the winder in accordance with customer demands and in accordance with changes in the characteristics of the web being severed. Therefore, due to the discrete operation of such winding mechanisms, a portion of the available time is utilized in the unproductive phases of replacing large rolls, changing the slitter settings in a cross-web dimension subject to customer demands, replacing cores for the narrow rows, and a variety of other functions with respect to the marking and storing of the smaller rolls.

A system which greatly simplifies the operation of the winder and the slitter mechanism is described in U.S. Patent No. 3,176,566 to H. R. Patterson, Jr. The system of this patent replaces manual positioning of the slitting devices with a precision remote positioning unit. Although the time of set-up and operation is greatly reduced with the system described in the aforementioned patent, such saving in time is not reduced to absolute minimum due to the necessity of an operator having to refer to production schedule sheets to determine the position of the slitters for a subsequent operation. Furthermore, additional delays resulted from the necessity of the winder operator having to manually mark the rolls with order designation, shipping information, warehouse storage, and other pertinent data.

Another, although related, problem is that of optimally scheduling the sequence in which the rolls are to be severed and in determining what pattern or arrangement of the slitters in a cross-machine direction shall be used in the slitting operation. Originally, this operation was accomplished purely by manual techniques. A human scheduler would arrange the orders of a given grade of paper or the like product with the object of attempting to reduce the trim waste. The trim waste is that portion of the larger roll which is not employed when it is divided by slitting to the customers small roll requirements. This method is slow and generally does not produce a cutting

pattern where the minimum amount of waste is achieved.

Therefore, an object of the present invention resides in the provision of a digital computer or large scale analogue trim computer to automatically adjust the position of one or more slitters.

Still another object of the present invention resides in the provision of a unit for marking the finished rolls with information such as order data, shipping data, and warehouse storage location.

These and other objects, features, and advantages of the present invention will be more fully realized and understood from the following detailed description when taken in conjunction with the accompanying drawings wherein:

FIGURE 1 diagrammatically illustrates in block form one embodiment of the present invention wherein digital control is employed in a slitter system;

FIGURE 2 diagrammatically illustrates in block form another embodiment of the present invention wherein analogue information is employed to controll the slitter system;

FIGURE 3 diagrammatically illustrates in block form still another embodiment of the present invention;

FIGURE 4 diagrammatically illustrates in block form a relatively simple embodiment of the present invention;

FIGURE 5 diagrammatically illustrates in block form the simplest embodiment for automatic control of a slitting system; and

FIGURE 6 is a schematic illustration of the electrical circuit diagram of the slitter positioning mechanisms of the present invention.

AS SHOWN ON THE DRAWINGS

With reference to the drawings in detail and in particular to FIGURE 1, there is shown an automatic slitter setting, roll marking, and roll allocation system constructed in accordance with the principles of the present invention. A digital computer **11** is supplied with and sorts information from a plurality of punched cards **12**. Information on the cards **12** is derived from order data sheets indicated generally by the reference number **13**. The order data sheets **13** include the customer's name, the finished size of roll required, and other pertinent data as found on standard order forms. This information must be reduced to compatible information on a suitable medium, such as the cards **12**, which will allow interpolation of such information by the digital computer **11**.

After sorting and reading the information on the cards **12**, the digital computer **11** delivers output signals in digital form to a display unit and control console **14** through a line **16**. Display unit **14** may be a line printer, cathode ray tube, or banks of lights located on the control console. The display unit **14** may be employed to indicate the position of any slitter for a subsequent slitting operation, customer identification, and/or grade of the paper being slit. The display unit **14** may, if desired, be similar to that provided with conventional digital draw display units. Selector switches **14***a* and **14***b* are provided on the control console; the switch **14***a* being numbered from one to the number of slitters in the system and the switch **14***b* being numbered from one to three. The switch **14***b* is employed for controlling the mode of display. In the preferred embodiment, the slitter position from the sheet edge or from some arbitrary base point of each slitter can be displayed in mode one by selecting the particular slitter number on the switch **14***a*. The second position of switch **14***b* could provide the roll width corresponding to the selection of a given number on the selector switch **14***a*. The third position of the switch **14***b* could provide a display of the trim loss from the paper web. In this mode, the percentage of trim loss on each pattern could be displayed. In addi-

tion, the switch **14***a* could be made inoperative, if desired, or could be used to select various displays such as inches lost, tons lost, percentage lost, lost product value in dollars, etc. with respect to the trim loss of the paper web.

The control console **14** further includes a set of switches, designated generally with the reference numeral **14***c*, for feeding information to the computer **11** not theretofore available from the cards **12**. Such manually fed information would readjust the computer **11** accordingly. This information may include, for example, changes in available trim width resulting from a reduced Fourdrinier wire width or terminal felt width. These and other factors would result in less useable paper are supplied to the computer **11** on a line **17** for integration with the information derived from the cards **12**.

A manual input station, indicated generally by reference numeral **18**, is connected to the digital computer **11** through a line **19** for manually inserting into the computer **11** such information as warehouse storage space availability. Information such as order data, shipping data, and customer code numbers is delivered to the digital computer **11** by way of the punched cards **12** and is delivered to a marking unit **20** through a line **21**. Furthermore, warehouse storage data from the manual input station **18** also passes through computer **11** to the marking unit **20**. Therefore, the marking unit **20** prints a label or prints directly on the paper web all the pertinent data necessary for proper handling. The label is then fixedly secured to the particular roll corresponding to the information on the label prior to shipment of the rolled web to warehouse storage.

Command signals from the digital computer **11** are delivered to a slitter control **22** through a line **23**. The slitter control **22** derives suitable control information indicative of digital command signals to control the operation of a plurality of slitter motors **24**. Control signal information from the slitter control **22** is delivered to the slitter motors **24** via a line **26**, and feedback information indicative of the actual position of the slitter is applied to the slitter control **22** from the slitter motors **24** via a line **27**. The slitter motors **24** may have associated therewith one or more positive sensing means to derive a feedback signal indicative of actual slitter position in such a manner as is well known in the art. Furthermore, the slitter control **22** includes suitable means which convert the actual position feedback signal to corresponding digital signal information which, in turn, is fed back to the computer **11** through a line **28**.

Connected to the slitter control **22** is a manual entry control **29** which actuates the slotter control **22** through a line **30**. The manual entry control **29** may be used to override any or all of the command signals delivered to the slitter control **22** from the compter **11**. The spacing between a slitting band and the corresponding slitting blade of a web slitting apparatus is controlled by a manual entry control **31** which delivers signal information to the slitter control **22** through a line **32** in such a manner as to control the distance between a slitter band and a corresponding slitter blade in increments of 0.0001 inch.

In operation, the plurality of punched cards **12**, each corresponding to a particular customer order, is fed into the digital computer **11** whereupon all of the cards are interpreted simultaneously. The information from the cards **12** is placed into a temporary storage. Information indicative of the useable width of the master roll being divided into smaller rolls is also fed into the digital computer **11**. The stored information from the punched cards **12** is then processed in such a manner as to select the combination of orders to be filled which will yield the least amount of trim waste from the master roll.

By way of example, it may be desired to divide a master roll having a useable width of 120 inches. Four punched cards **12** representing four different customer orders, each requiring a rolled web of a different width may be delivered to the computer **11**. The computer **11** evaluates the various combinations of web widths requested by the customers and selects the combination of orders to be filled which yields the minimum waste when slitting the master roll. The four widths may correspond to 24 inches, 30 inches, 36 inches, and 72 inches. Only one combination of the orders to be filled will produce maximum efficiency of the 120 inch master roll. The combination of the 24 inch, 30 inch and 36 inch rolls will produce a total width of 90 inches to be split from the master roll leaving 30 inches of unused roll which may or may not be used to fill a subsequent order. Furthermore, the combination of 30 inches, 36 inches, and 72 inches provides a total width of 138 inches which exceeds the total useable width of the master roll. On the other hand, a combination of 72 inches and 36 inches yields a useable width of 108 inches thereby providing a waste width of only 12 inches.

Therefore, digital information corresponding to the orders for the 36 inch and the 72 inch width rolls will be propagated from the digital computer **11** to the slitter control **22** which, in turn, positions the corresponding slitters as necessary. The slitters which are not required for the slitting of a particular combination of rolls from a master roll may be positioned at some remote location so as not to interfere with the operation of the slitters used to divide the master roll. That is, a web transport slitting apparatus may be provided with six or more slitters, and in accordance with the example hereinabove, only three slitters are required to divide the master roll into a 36 inch width and a 72 inch width. However, a fourth slitter may be used to trim the unuseable portion of the web thereby placing the 12 inch width remainder of the roll in usable condition.

Shown in FIGURE 2 is an automatic slitter setting system using an external analogue comparator. A computer **41** receives a plurality of punched cards **42** which contain information, such as available trim or order data, from sheets indicated by the reference numeral **43**. The computer **41** is connected to a selector unit **44** which performs to actuate one of a first plurality of switches **50–55** and a corresponding one of a second plurality of switches **57–62**. A switch **49** is provided with one contact **46** thereof connected between the selector **44** and the switches **50–55** and the switches **57–62**. Another contact **48** of the switch **49** is connected to a manual selection station **47**. By operation of the switch **49**, the switches **50–55** and the switches **57–62** may be operated either automatically from the computer **41** or manually from the station **47**.

Digital information from the computer **41** is delivered to a digital to analogue converter **63** through a line **64**. The converter **63** changes the digital information to analogue form for use by a summer amplifier **66**. Signal information corresponding to a slitter position is delivered to the analogue summer amplifier **66** through a line **68** from a selector switch **69** when engaged with a contact **70**. Signal information corresponding to a slitter position is derived from the digital to analogue converter **63** and represented as a direct current voltage from 0 to 50 volts and applied to the contact **70** through a line **71**. A 50-volt source is connected through a potentiometer **72** to a contact **73** to provide a manual mode of operation for positioning the respective slitters.

With one of the switches **50–55** closed, signal information corresponding to the actual position of a corresponding slitter is delivered to the analogue summer amplifier **66** through a line **76**. The analogue summer amplifier **66** then compares the signal information applied thereto through lines **68** and **76** to develop an output signal corresponding to the difference or error between the actual position of the slitter and the desired position of the slitter. This error signal is delivered to an analogue to

digital converter 77 through a line 78. The signal information from the analogue to digital converter 77 is then fed back to the digital computer 41 through a line 75.

The error signal information from the output of the analogue summer amplifier 66 is also fed through one of the switches 57–62, corresponding to the particular slitter being positioned, to one of a plurality of amplifiers 79, 80, 81, 82, 83, and 84. The error signal information is delivered to one of the corresponding power amplifiers 79–84 to drive the corresponding slitter drive motor indicated generally by reference numeral 86.

In operation, customer order information is punched into the plurality of cards 42 and fed into the computer 41 in much the same manner as mentioned hereinabove. In the automatic mode of operation, the movable contactor 49 engages the stationary contact 46 and the selector 44 actuates one of the switches 50–55 and one of the switches 57–62. By way of example, the switch 50 and the switch 57 may be closed providing a signal indicative of the position of the first slitter on the line 76 and providing an error signal to the amplifier 79. Signal information corresponding to the actual position of the first slitter is delivered to the amplifier 66 wherein the signal information is compared with signal information corresponding to the desired new position of the slitter and a corresponding error signal is developed at the output of the amplifier 66 and applied to the power amplifier 79 through the switch 57. The amplifier 79 then drives the appropriate slitter drive motor to move the corresponding slitter until the demanded position from the computer 41 is equalized by the feedback signal on line 76. At this time, the signal information from the analogue summer amplifier 66 is zero. The zero reading from the output of amplifier 66 is then delivered to the digital computer 41 through the analogue to digital converter 77 and the line 75 thereby generating a suitable shift signal to open switches 50 and 57 and close switches 51 and 58 so as to position the second slitter. Prior to the generation of such a shift signal, however, a tighten signal is provided for tightening a slitter band against a corresponding slitter blade. The operation of positioning the second and subsequent slitters is substantially the same as the operation of positioning the first slitter mentioned hereinabove.

In the manual mode of operation, the selector switch 49 may be placed in contact with stationary contact 48 and suitable manual means may be provided to selectively energize corresponding switches 50 and 57, 51 and 58, 52 and 59, 53 and 60, 54 and 61, 56 and 62. Also in the manual mode of operation the selector switch 69 may be placed in contact with stationary contact 73 and an analogue signal corresponding to a slitter position may be applied to the analogue summer amplifier 66 by varying the potentiometer 72.

A unit 85 provides a signal to the computer 41 whenever one slitter position interferes with another adjacent slitted position. A console on the computer 41 may be employed for indicating not only such a position interference, but such information as that provided by the display unit 14 of FIGURE 1.

Shown in FIGURE 3 is a simplified form of an automatic slitter setting system wherein all comparison signals are derived internally of the computer. A computer 91 receives a plurality of punched cards 92 which, in turn, are processed to include order or trim data from order forms such as indicated by reference numeral 93. Feedback information indicative of the actual position of each of the slitters is fed to an analogue to digital converter 94 through a plurality of lines 96, 97, 98, 99, 100, and 101. Each of the lines 96–101 may be provided with suitable selective means to apply the signal information to the analogue to digital converter 94 selectively one at a time. However, the analogue to digital converter 94 may include selector means therein, thereby obviating the need of external selector means.

The output of the analogue to digital converter 94 is delivered to the digital computer 91 through a plurality of lines 102, 103, 104, 105, 106, and 107. Each of the lines 102–107 correspond to a particular slitter, and signal information corresponding to the position of each slitter may be individually selected and compared with the desired position of the particular slitter and an error signal developed within the digital computer 91. The error signal corresponding to the new slitter position is then delivered to each of the slitters through a plurality of lines 108, 109, 110, 111, 112, and 113 from the output of computer 91.

The digital computer 91 is provided with a priority interrupt means which is applied thereto through a line 114. The priority interrupts signals any interference between adjacent slitters.

Shown in FIGURE 4 is another embodiment in simplified form of an automatic slitter setting system of the present invention. A digital computer 121 receives information from the plurality of punched cords 122 which, in turn, have order data applied thereto from order sheets, such as indicated by the reference numeral 123. Each of the slitters have suitable feedback means to develop digital signal information indicative of the actual position of the slitter. These feedback signals may be derived from a gear driven shaft position encoder or digital position transducer secured to each slitter. Such digital signal information is supplied to the digital computer 121 through a plurality of lines 126, 127, 128, 129, 130, and 131. Actual positions of the feedback signals in the form of a digital signal information obviates the need of analogue to digital converters as shown in FIGURE 3.

The computer 121 compares the desired position of each slitter with the actual position thereof to develop an error signal at the output of the computer 121 which is delivered to respective ones of the slitter positioning controls through a plurality of lines 132, 133, 134, 135, 136, and 137. The slitters may be controlled by stepping motors responsive to the digital signals on lines 132–137 and/or by clutch controls responsive to the digital signals. Priority interrupt means are provided for supplying signal information to the computer 121 through a line 138 whenever slitter interefrence occurs.

Shown in FIGURE 5 is a further modification of a more simplified automatic slitter setting system. A digital computer 141 is provided to receive a plurality of punched cards 142 which, in turn, have order data applied thereto from order sheets, such as indicated by the reference numeral 143. The output of computer 141 is delivered to respective slitter positioning controls through a plurality of lines 146, 147, 148, 149, 150, and 151 to control the position of the respective slitter associated with each of the lines. In this simplified form of the invention, no feedback information is required to give actual position signals from the slitters. The movement of the slitters is controlled by stepping motors applied thereto. The movement of each slitter originates from a given reference point and the digital computer 141 merely keeps track of the number of pulses applied to each one of the stepping motors.

The digital computer 141 may have a plurality of manual inputs such as a selectable index input, a slitter tightening input, and a slitter inoperative input. The manual index input selects the starting point for all of the slitters so that the digital computer 141 can keep track of the movement of the slitters relative to a starting point. The slitter tightening input merely adjusts the relative position between the slitter blade and the slitter roller in increments of 0.0001 inch. The slitter inoperative input manually places any unused slitters in an inoperative state so as not to interfere with the normal operation of the slitter apparatus.

Shown in FIGURE 6 is still another embodiment of an automatic slitter setting system and is shown used in conjunction with a remote position control system. The

remote position control system as shown in FIGURE 6 is similar to that shown in the patent issued to H.R. Patterson, Jr., Patent No. 3,176,566. A digital computer **161** is provided for receiving a plurality of punched cards **162** which, in turn, receive order data from sheets generally indicated by the reference numeral **163**.

A pair of digital stepping motors **164** and **166** are connected to outputs of the digital computer **161**. The motors **164**, **166** are provided with output shaft **167** and **1968**, respectively, the angular position of each being indicative of outputs from the computer **161**. The output shaft **167** drives a selsyn generator **169** which is connected to a control transformer **170** having an output signal indicative of the position of the shaft **167**. The output of the control transformer **170** is connected to an amplifier **171** which provides a feedback signal on lines **172** and **173** to an analogue to digital converter **174**. The analogue information from the amplifier **171** is converted to digital information and is supplied to the digital computer **161**. The output of the amplifier **171** controls the position of slitter band.

In a similar manner, the output shaft **168** of the motor **166** is connected to a selsyn generator **177** which provides an output signal from a corresponding control transformer **178** to an amplifier **179**. The amplifier **179** is connected by leads **180** and **181** to the analogue to digital converter **174** for providing a feedback signal to the digital computer **161**. The output of the amplifier **179** controls the position of the slitter blade in accordance with signals provided from the digital computer **161** to the stepping motor **166**.

As described in the patent to H. R. Patterson, Jr., Patent No. 3,176,566, the slitter blade and slitter band are each supported on respective carrier members. These carrier members are slidably mounted on respective rails which extend in the cross-machine direction for positioning the respective slitter band and slitter blade. It is to be understood, however, that other positioning structures may be employed. A positioning motor **182** (FIG URE 6) is mounted on the carrier member which supports the band and a positioning motor **183** is mounted on the carrier which supports the blade. The motors **182**, **183** are connected through on-off switches **184***a* and **184***b* to a pair of terminals **186** and **187** disposed for connection to a source of power. During the positioning operation of the slitter band and the slitter blade, the switches **184***a*, **184***b* are maintained closed for continuous operation of the positioning motors **182**, **183**.

An output shaft of the motor **182** is connected through a gearbox and through a forward and a reverse clutch **188** and **189** to a pinion which engages a rack secured to the respective rail. In this manner, energization of one of the clutches **188**, **189** engages the output shaft of the motor **182** through the gearbox to the rack and the pinion for moving the slitter band along the rail. The positioning motor **183** for the blade is similarly connected through a gearbox and through a forward and a reverse clutch **190** and **191** to a pinion which engages a rack secured to the rail which supports the blade thereon.

The clutches **188**, **189** are energized by the amplifier **171** which is connected to an output of the control transformer **170**. Similarly, the clutches **190**, **191** are connected to the output of the amplifier **179**, which output is proportional to the output of the control transformer **178**. A rotor **192** of the control transformer **170** and a rotor **193** of the control transformer **178** are each connected to respective pinions and, when rotated therewith, decrease the outputs of the respective control transformers **170**, **178** until a zero output is reached and the respective clutches **188–191** are deenergized.

In operation, therefore, the stepping motor **164** is driven in accordance with signals from the digital computer **161** and angularly positions a rotor **194** of the selsyn generator **169** in accordance with such signals. Angular movement of the rotor **194** produces an output from the control transformer **170** which is proportional to the angular displacement of the rotor **194**. This output is amplified and controls energization of a respective one of the clutches **188**, **189**. Energization of one of the clutches **188**, **189** moves the carrier member along the rail and, at the same time, changes the angular position of the rotor **192** of the control transformer **170**. As the rotor **192** is displaced angularly an equal amount to the angular displacement of the rotor **194**, the output of the control transformer **170** reduces to a zero condition. Therefore, positioning of the band on the rail is provided in accordance with output signals from the digital computer **161** to the stepping motor **164**.

Energization of the stepping motor **166** controls the positioning of the slitter blade in a like manner to the slitter band positioning structures. A rotor **196** of the selsyn **177** is angularly displaced by the stepping motor **166** in accordance with signals from the digital computer **161**. The control transformer **178** provides an output in accordance with the angular displacement of the rotor **196** which is amplified by the amplifier **179** to energize the clutches **190**, **191**. Energization of one of the clutches **190**, **191** positions the carrier member which supports the blade on the rail and, at the same time, changes the angular position of the rotor **193** of the control transformer **178**. When the rotor **193** has been displaced the same as the angular displacement of the rotor **196**, the output of the control transformer **178** is reduced to a zero condition to deenergize the clutches **190**, **191**.

An output of the control transformers **170**, **178** is also supplied through the respective amplifiers **171**, **179** to the analogue to digital converter **174** for providing feedback information to the digital computer **161** of the actual position of the slitter band and the slitter blade on the respective rails. Each of the amplifiers **171**, **179** should include a phase-sensitive detector for indicating the direction of rotation of the rotors **192**, **193** and for proper energization of a respective one of the clutches **188–191** for movement of the carrier members in the correct direction along the rail.

The stator windings of the selsyn generator **177** are connected to respective stator windings of the control transformer **178** through switches **197**, **198** and **199** in one position of the switches **197–199** as shown in FIGURE 6. In another position of the switches **197–199** the stator windings of the control transformer **178** are connected to the stator windings of the selsyn generator **169**. This connection of the selsyn generator **169** to the control transformer **178** controls the position of the blade in accordance with the angular displacement of the rotor **194**. In a third position of the switches **197–199** the stator windings of the control transformer **178** are connected to the stator windings of a selsyn generator **200** having a rotor **201** thereof mechanically coupled to the rotor **192** of the control transformer **170** and to the pinion which positions the slitter band. This connection of the selsyn generator **200** to the control transformer **178** causes the slitter blade to follow the movement of the slitter band precisely.

It is often desirable to employ a plurality of pairs of slitter units in conjunction with a single winding apparatus. In such instances, each slitter blade is mounted on the same rail with one another and each slitter band is mounted on another rail with one another. With more than one unit mounted on a single rail, it is necessary and desirable to automatically deenergize the drive units of the slitters when one is moved against and interferes with the other. Furthermore, it is desirable to deenergize the drive when the slitters reach a certain limit of travel in one direction or another in the cross-machine direction.

According to this invention, a piar of switches **202** and **203** are mounted on opposite sides of the carrier member which supports the band and the motor **182** thereon. The switches **202**, **203** are disposed for engaging

either a fixed stop or an adjacent carrier member and opening upon such engagement to deenergize the corresponding clutch **188, 189.**

As shown in FIGURE 6, the switches **202, 203** are respectively connected between the amplifier **171** and the forward clutch **188** and the reverse clutch **189.** Similarly, a pair of switches **204** and **206** are respectively connected between the amplifier **179** and the forward clutch **190** and the reverse clutch **191.** The switches **204, 206** are mounted on opposite sides of the carrier which supports the blade and the positioning motor **183** thereon and are disposed for engaging either a fixed stop of an adjacent blade carrier member. The switches **202, 203, 204** and **206** are connected to a priority interrupt unit **207** which provides corresponding signals to the digital computer **161** to indicate an interference between adjacent slitter units. The digital computer **161** may be provided with a read-out console for indicating such slitter interference, if the computer **161** is not capable of correcting the difficulty.

Means are provided for locking the carrier members onto the rails when the correct position of the slitter band and the slitter blade has been achieved. When the desired position has been achieved, feedback information from the amplifiers **171, 179** signals the digital computer **161** to open the on-off switches **184*a*, 184*b*** to deenergize the positioning motors **182, 183.** A relay **208** is also connected through the switches **184*a*, 184*b*** to the source of power on the terminals **186, 187,** which relay includes a plurality of normally closed switches **209, 210, 211** and **212.**

A current source is connected to a pair of terminals **213** and **214** and the switches **209–212** are each connected between the terminal **213** and one of the clutches **188–191.** The terminal **214** is connected to a common line of each of the clutches **188–191.** When the on-off switches **184*a*, 184*b*** are closed, such as during the positioning operation of the slitter units, the motors **182, 183** are energized and the relay **208** is also energized to maintain the switches **209–212** open for disconnecting the source of current at the terminals **213, 214** from the clutches **188–191.** However, when the on-off switches **184*a*, 184*b*** are open, the positioning motors **182, 183** and the relay **208** are deenergized, which deenergization of the relay **208** causes closing of the switches **209–212** to connect the source of current at the terminals **213–214** to the clutches **188–191.** With the clutches **188–191** energized and with the motors **182–183** deenergized, the slitter units are locked in position because of high frictional resistance to rotation due to a large speed reduction in the gear reducing units of each motor.

Individual drive motors may be employed for driving the band and the blade of each slitting unit or, if desired, the blade may be rotated by frictional engagement with the band. In the latter case, the blade must be tightened against the band for effecting the frictional drive thereof. Therefore, before the positioning motors **182, 183** lock the carrier members on the respective rails, it may be necessary to move the positioning motor **183** one or more small increments. For effecting such movement, a tightness input **216** is provided which is connected to the motor **166** to cause a small increment of movement of the blade with respect to the band.

The slitter setting system of the present invention may take other forms because of the computer control employed as described above. One such form or modification involves replacing the selsyn generators **169, 177** and the control transformers **170, 178** with an electronic feedback device which senses the position of each slitter unit. The stepping motors **164, 166** in this form of the invention would be connected directly to the slitter blade and slitter band respectively. Also, the stepping motors **164, 166** would be connected to the computer **161** to provide precision settings of the slitters. This form of the invention eliminates a major fraction of the required control equipment illustrated in FIGURE 6, since these functions would be accomplished internally in the digital computer **161.** An even simpler form of this system (and thus less expensive and more reliable) would be one in which no feedback regarding position whatsoever would be employed. In such a version of the present invention, precision stepping motors would drive the slitters and the position of the slitters would be determined by maintaining an algebraic sum of the pulses supplied to the slitter in a storage of the computer memory. This sum is linearly related to the position from a zero point which can be defined arbitrarily.

The system of this invention is particularly advantageous in combination with the illustrated form of the slitter structure shown in U.S. Patent No. 3,176,566, wherein the blade is in the form of an essentially flat disk having opposed surfaces connected by a tapered or conical peripheral surface which defines a sharp cutting edge. The peripheral edge portion of the surface engages a peripheral edge portion of the lower band to obtain the shearing action. As previously mentioned, the band may drive the blade by a frictional engagement therewith and, therefore, means are provided for supplying small incremental pulses to the blade stepping motor **166** for tightening the slitter blade against the corresponding slitter band to facilitate the frictional engagement between the two. This tightness input may be controlled by the computer **161** upon the occurrence of a zero feedback delivered thereto or may be controlled manually, if desired.

Although a specific embodiment of the invention has been described herein, it is not intended to limit the invention solely thereto, but to include all of the obvious variations and modifications within the spirit and scope of the appended claims.

We claim as our invention:

1. A system for controlling the position of a plurality of slitter units disposed for dividing a supply roll of web material into at least two smaller rolls in accordance with demanded size requirements, comprising a computer responsive to a plurality of inputs each corresponding to a respective demanded size requirement and for selecting a group of said inputs which provides a minimum amount of waste when the supply roll is severed in accordance with the demanded size requirements of said group of inputs, a plurality of positioning motors with each one connected to a respective one of the slitter units and responsive to the selected inputs from said computer for positioning said units in accordance with the size requirements of the selected inputs, including a pair of digital stepping motors connected to outputs of said computer and each having a shaft output proportional to the selected group of inputs, and means for energizing each of said positioning motors in accordance with the shaft output of the respective one of said stepping motors.

2. A system for controlling the position of a plurality of slitter units disposed for dividing a supply roll of web material into at least two smaller rolls in accordance with demanded size requirements, comprising a computer responsive to a plurality of inputs each corresponding to a respective demanded size requirement and for selecting a group of said inputs which provides a minimum amount of waste when the supply roll is severed in accordance with the demanded size requirements of said group of inputs, a plurality of positioning motors with each one connected to a respective one of the slitter units and responsive to the selected inputs from said computer for positioning said units in accordance with the size requirements of the selected inputs, including means for sensing the position of each slitter unit from a reference point and providing feedback signals indicative of such positions to said computer, said computer being responsive to said feedback signals for energizing said positioning motors.

3. The system as defined in claim 3 wherein said sensing means includes a pair of shaft position encoders each connected to a respective one of said positioning motors.

4. The system as defined in claim 3 including an analogue to digital converter responsive to said encoders and connected to said computer for supplying feedback signals thereto from said encoders proportional to the position of each slitter unit from a reference point.

5. A system for controlling the position of a plurality of slitter units disposed for dividing a supply roll of web material into at least two smaller rolls in accordance with demanded size requirements, comprising a computer responsive to a plurality of inputs each corresponding to a respective demanded size requirement and for selecting a group of said inputs which provides a minimum amount of waste when the supply roll is severed in accordance with the demanded size requirements of said group of inputs, a plurality of positioning motors with each one connected to a respective one of the slitter units and responsive to the selected inputs from said computer for positioning said units in accordance with the size requirements of the selected inputs, wherein said computer provides digital pulses at outputs thereof and said positioning motors being responsive to each of said pulses for moving a respective slitter unit a predetermined distance, said comptuer including memory means for storing the number of pulses supplied to said positioning motors and comparing that number with the demanded size requirements.

6. A system for controlling the position of a plurality of slitter units disposed for dividing a supply roll of web material into at least two smaller rolls in accordance with demanded size requirements, comprising a computer responsive to a plurality of inputs each corresponding to a respective demanded size requirement and for selecting a group of said inputs which provides a minimum amount of waste when the supply roll is severed in accordance with the demanded size requirements of said group of inputs, a plurality of positioning motors with each one connected to a respective one of the slitter units and responsive to the selected inputs from said computer for positioning said units in accordance with the size requirements of the selected inputs, including a digtal to analogue converter connected to outputs of said computer, an analogue summer connected to outputs of said converter and connected to each of said positioning motors, and feedback means having outputs indicative of slitter positions connected to said summer.

7. The system as defined in claim 6 including an analogue to digital converter connected from an output of said summer to said computer.

8. A system for controlling the position of a plurality of slitter units disposed for dividing a supply roll of web material into at least two smaller rolls in accordance with demanded size requirements, comprising a computer responsive to a plurality of inputs each corresponding to a respective demanded size requirement and for selecting a group of said inputs which provides a minimum amount of waste when the supply roll is severed in accordance with the demanded size requirements of said group of inputs, a plurality of positioning motors with each one connected to a respective one of the slitter units and responsive to the selected inputs from said computer for positioning said units in accordance with the size requirements of the selected inputs, including a plurality of stepping motors connected to said computer and having shaft outputs proportional to said group of inputs, a plurality of selsyn generators each connected to a respective one of said stepping motors, a plurality of control transformers each responsive to a respective one of said generators, a plurality of amplifiers each connected to an output of a respective one of said transformers, each of said positioning motors being responsive to outputs of a respective one of said amplifiers.

9. The system as defined in claim 8 including a plurality of clutches each connected between a respective one of said positioning motors and a respective slitter unit, each of said clutches being connected to outputs of a respective one of said amplifiers, each of said amplifiers including a phase-sensitive detector.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,488,479 Dated January 6, 1970

Inventor(s) MARION A. KEYES and ROBERT A. BEACHLER

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

Column 1, line 5, after "53511", insert --, assignors to Beloit Corporation, Beloit, Wisconsin, a corporation of Wisconsin--.

Column 3, line 51, change "slotter" to --slitter--.

Column 6, line 20, change "cords" to --cards--.

Column 7, line 10, change "1968" to --168--.

Column 8, line 72, change "piar" to --pair--.

Column 11, line 1, change "3" to --2--; line 27, change "comptuer" to --computer--; line 44, change "digtal" to --digital--.

SIGNED AND
SEALED
AUG 25 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

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