

**May 5, 1970**

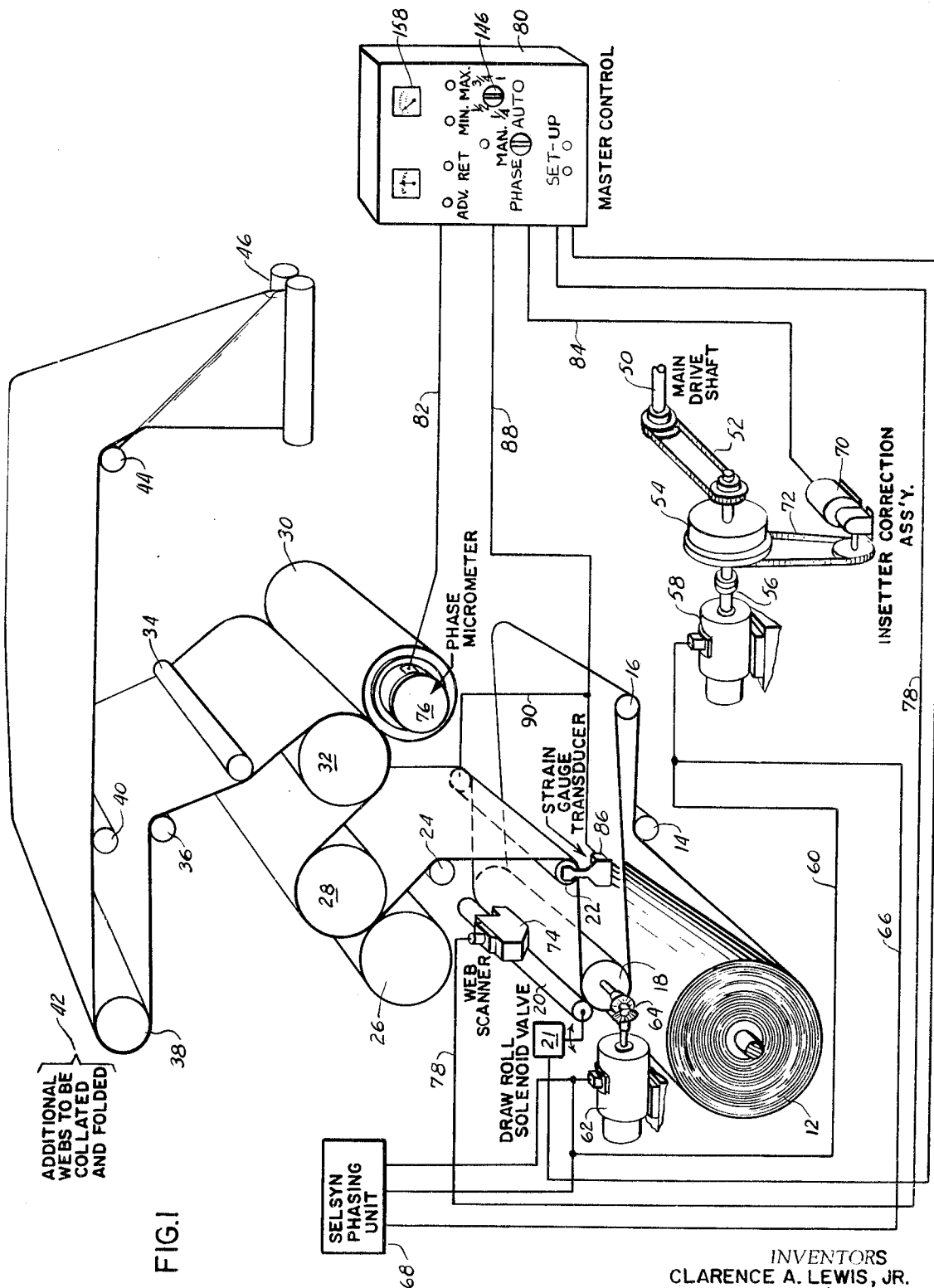
C. A. LEWIS, JR., ET AL

**3,510,036**

INSERTER AND SPLICER WITH REGISTER CONTROL FOR A REPRINTED WEB

Filed March 29, 1968

3 Sheets-Sheet 1



INVENTORS  
CLARENCE A. LEWIS, JR.  
DAVID GORDEMER

BY

James and Franklin

**ATTORNEYS**

May 5, 1970

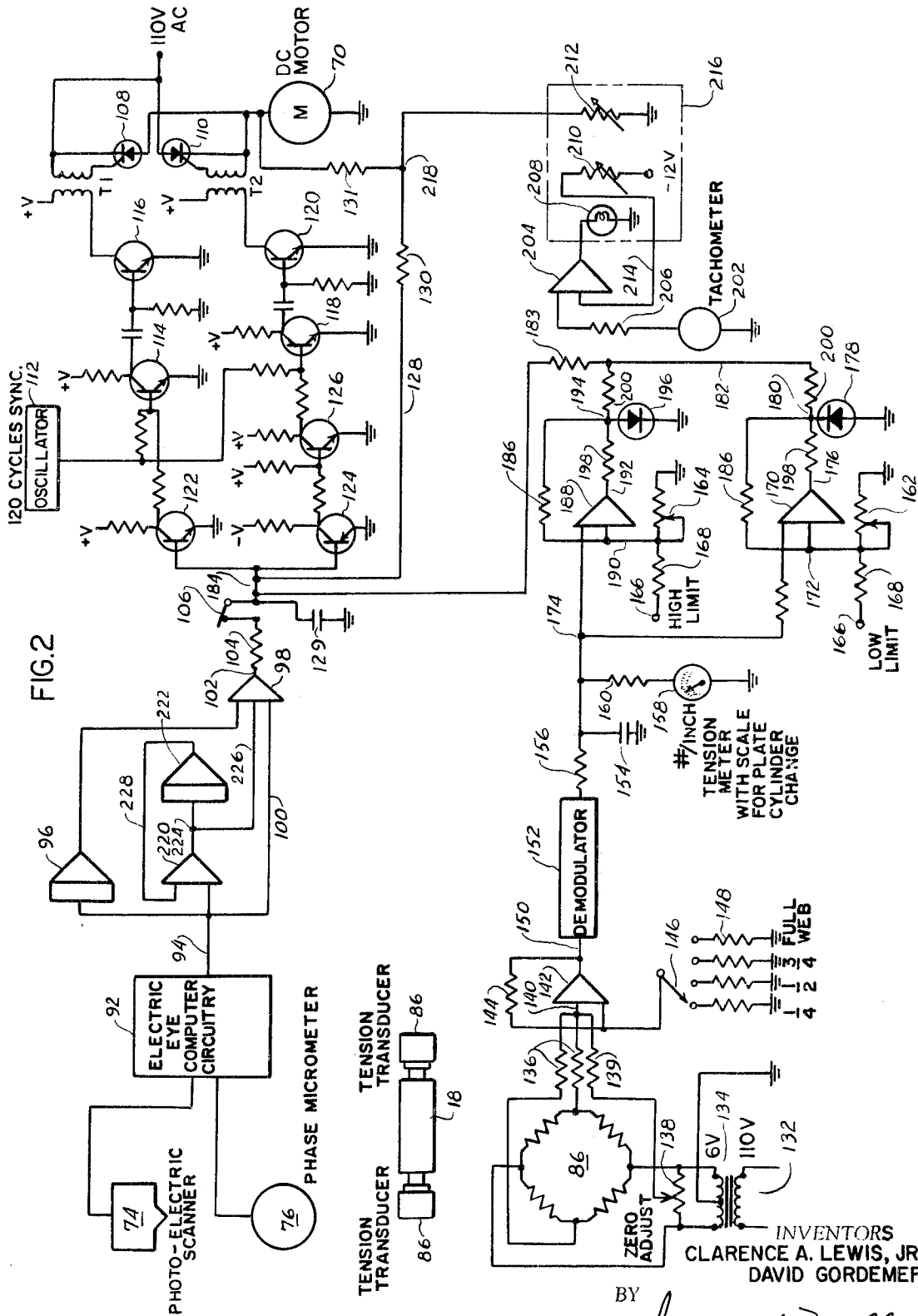
C. A. LEWIS, JR., ET AL

3,510,036

INSERTER AND SPLICER WITH REGISTER CONTROL FOR A REPRINTED WEB

Filed March 29, 1968

3 Sheets-Sheet 2





1

3,510,036

## INSERTER AND SPLICER WITH REGISTER CONTROL FOR A REPRINTED WEB

Clarence A. Lewis, Jr., Kinnelon, and David Gordermer,  
Rockaway, N.J., assignors to Bobst Champlain, Inc.,  
Roseland, N.J., a corporation of New York

Filed Mar. 29, 1968, Ser. No. 717,152

Int. Cl. B65h 23/20

U.S. Cl. 226—2

38 Claims

### ABSTRACT OF THE DISCLOSURE

A preprinted web is scanned to detect a registration error relative to a further operation on the web, and the tension is raised or lowered to maintain registration. The actual web tension is continuously and directly measured by strain gauge means, and is limited to a high limit to prevent breaking the web, and to a low limit which prevents "wandering" of the web. The web tension is automatically reduced to the lower limit during automatic splicing, and until the splice leaves the system where it is under tension. A tab of retroreflective tape is adhered to one end of the new preprinted roll in a desired location relative to the preprint on the new web, and the end of the roll is scanned by means of a retroreflective scanner, which overcomes difficulties caused when attempting to use an ordinary mark and scanner.

### Background of the invention

Publications, typically newspapers, often use a preprinted quality web, usually in color, which is inserted into the newspaper being printed. The other sheets are being printed in black and white by means of printing couples driven in unison from a common drive shaft. The back of the preprinted sheet may be printed in black and white as part of the newspaper printing operation, and even the front of the sheet may have local information added thereto, for example the name and address applicable locally to advertisements on the color preprinted sheet. This requires registration, and it is already known to maintain such registration by varying the tension applied to the preprinted web, thereby slightly varying the repeat length. However, if an error correction is made too rapidly by excessive increase in tension, the web may be broken, and on the other hand, if a correction requiring decrease of tension is made too rapidly, there may be a loss of control of side-to-side registration, frequently termed "wandering" of the web.

Another problem is to maintain maximum production by splicing with a tight web or "on the fly," instead of stopping the press to splice by hand. Apparatus for such splicing is known, but a major difficulty is that the splice is a point of weakness which tends to break under the web tension provided for registration control.

Thus, to maintain registration by varying web tension, leads to web breakage at one extreme, and wandering at the other, and has prevented success in automatically splicing with a continuously running tensioned web, the freshly made splice being weaker than the web itself.

### Summary of the invention

As before, the web is scanned to detect a registration error, and the tension on the preprinted web is raised

2

or lowered to so increase or decrease the repeat length as to maintain registration. In accordance with the invention, the actual web tension is continuously and directly measured by strain gauge means, and an increase in web tension is limited to a predetermined desired high limit which is less than that which would break the web. Conversely a decrease in web tension is limited to a predetermined desired low limit which is high enough to prevent "wandering" of the web. The web tension may be varied by means of brake or a vacuum box or tension straps, but in preferred form the web is fed between a metal draw roll and a rubber roll, because that does not mar or scuff the printed matter; is independent of the reel stand or turnover stand tension; is more accurate and stable during register changes; and the feed is independent of the printing couples which, for letterpress and offset press, have gaps between plates on the plate cylinder. The draw roll is driven by the main drive shaft at a speed approximating the desired web speed, and a slight servo motor correction is fed into the drive through a 360 degree continuous running register of the differential or planetary gear type, thereby varying the speed of the draw roll to provide a desired web tension which is held between the predetermined lower and upper limits of web tension.

The web tension for newsprint may range normally from say 1½ to 3 pounds per linear inch of web width, but the lower limit may be as low as say ½ pound per linear inch. In accordance with a further feature of the present invention, the web tension is automatically reduced to the lower limit during the splicing operation, and until the splice leaves the system so that it is no longer under breaking tension. There is a delay means the running out of which restores normal web tension between the aforesaid limit values and as needed for registration. The delay may be enough for the preprinted web to be collated with other webs being printed and to reach the folder and cutter.

With a preprinted web the splicing operation must secure registration of the preprint on the expiring and new webs. A tab of retroreflective tape is adhered to one end of the new roll in a desired location relative to the preprint. The roll is later brought up to approximate web speed, and the end of the roll is scanned by means of a retroreflective scanner. This is found to give a strong signal without background interference, and it overcomes difficulties which have arisen when attempting to use an ordinary mark scanned by an ordinary scanner, because the end of the paper roll is not a precision surface with fixed location.

The foregoing and additional features of the invention are described in the following detailed specification, which is accompanied by drawings in which:

FIG. 1 is a schematic diagram showing apparatus for additional printing on both sides of a preprinted web;

FIG. 2 is an electrical diagram applicable to the apparatus shown in FIG. 1;

FIG. 3 is a perspective view of a preprinted roll;

FIG. 3A shows the same prepared for automatic splicing;

FIG. 4 is a pulse diagram explanatory of the operation of the splicing apparatus;

FIG. 5 is a schematic electrical diagram showing the circuitry of the splicing apparatus; and

FIG. 6 is explanatory of the retroreflective scanner.

Referring to FIG. 1, the preprinted web roll is shown at 12 and the web drawn therefrom passes around rollers 14 and 16 to a metal draw roll 18, which is driven nearly in synchronism with the printing couples. The web is squeezed between draw roll 18 and a rubber roll 20 for accurate feed of the web. The pressure may be obtained by means of air cylinders, controlled by a solenoid valve 21. The web then passes around a roll 22 to a guide roll 24 leading to a first printing couple, which in the present case comprises a plate cylinder 26 and a blanket cylinder 28.

The web then runs to another printing couple for printing the opposite side of the web, this comprising a plate cylinder 30 and a blanket cylinder 32. As here shown these printing couples are of the letter press type, and print in black and white, the preprint being in color.

The web then runs over guide rollers 34, 36, 38 and 40. It may be combined or collated with additional webs supplied at 42, and the multiple webs may pass around a guide roller 44 leading to folding and cutting mechanism schematically suggested at 46, where the newspapers are completed. For magazine presses the product may be called "signatures."

The printing couples 26, 28, 30 and 32 may be geared together and are driven in unison with printing couples for additional webs by means of a main drive shaft a fragment of which is indicated at 50. This drive shaft is mechanically connected to the printing couples, and it also drives the draw roll 18 but with provision for a slight speed correction. The drive for this purpose is through a chain or timing belt 52 leading to a 360 degree continuous running register of known planetary gear (also called differential gear) type shown at 54. In the particular apparatus here illustrated it was not convenient to mechanically connect the output shaft 56 of the gear box 54 directly to the draw roll 18, and it therefore is applied to a Selsyn master unit 58 electrically connected by cable 60 to a Selsyn slave motor 62, geared at 64 to the draw roll 18. An additional cable is shown at 66 connected to a Selsyn phasing unit 68 for applying power to the Selsyn units. This part of the apparatus may be conventional, and the net result is as though the output shaft 56 of differential gear box 54 were geared directly to the draw roll 18.

An error in registration is determined by means of a web scanner 74, and a phase micrometer 76 is here shown connected to the shaft of the plate cylinder 30, but it might equally well be connected to the shaft of one of the other cylinders or to the main drive shaft. The signal from web scanner 74 is supplied through conductor 78 to computer circuitry in a control panel indicated at 80. The scanner 74, phase micrometer 76, and computer circuitry may be one of the types sold by the Registron Division of Bobst Champlain, Inc., located at Roseland, N. J., and identified as "Registron" models C-372, C-350, and R-500. The signal from phase micrometer 76 is supplied through conductor 82 to the circuitry at 80, and the resulting error correction signal from the computer is supplied through cable 84 to the correction motor 70.

In accordance with the present example, the actual web tension is measured by means of strain gauge transducers. Such a transducer is schematically represented at 86 and is connected by cable 88 to the computer circuitry at panel 80. Another such transducer is located at the other end of roll 22, and is connected into the circuitry by cable 90. In practice there are preferably four transducers connected in bridge form, as described later.

Referring now to FIG. 2 of the drawing, the scanner 74 and phase micrometer 76 are shown connected to computer circuitry at 92 to deliver an error signal at 94. The correction motor is shown at 70, and in the present case is a DC motor controlled through silicon

controlled rectifiers in much the same manner as is described in Pat. No. 3,355,640, issued Nov. 28, 1967, and entitled "Bidirectional Electrical Servo System".

The circuitry shown in box 92 may be one of the "Registron" Models C-350, C-372 or R-500 previously mentioned. The proportional error signal delivered at 94 may be plus or minus. It is here utilized with integration circuitry much like that described more fully in a copending application Ser. No. 599,929, filed Dec. 7, 1966, and entitled "Web Control Systems with Integrator." The proportional error signal is integrated at 96 and the integrated error signal is supplied to a summing amplifier 98. This is a miniaturized integrated circuit sometimes called an operational amplifier, an example of which is the Model 709 made by Fairchild Semiconductor of Mountain View, Calif., a Division of Fairchild Camera and Instrument Corporation.

The proportional error signal is supplied on the conductor 100 to the summing amplifier 98, and the summation of these two signals (meaning the original proportional error signal and the integrated error signal) appears at 102. Resistor 104 serves merely to change the voltage signal to a current. Switch 106 is normally closed and the signal at 184 is used to control the correction motor 70. This is a DC motor, and its armature is energized from an ordinary AC power supply (usually sixty cycles) indicated in the upper right-hand corner of the diagram as 110 volt AC. The supply is under the control of either silicon controlled rectifier 108 or 110, to supply rectified power to the motor 70 in one polarity or the other. The motor receives only the alternate half waves, these being either the positive half waves, or the negative half waves. To accomplish this there is a slave frequency doubler or synchronous double frequency pulse source indicated at 112, and the 120 cycle pulse is led to AND gates represented by transistors 114 and 118.

The signal from the summing amplifier 98 is supplied to transistors 122 and 124, one being of the NPN type, and the other being of the PNP type, so that one conducts for one polarity signal, and the other conducts for the opposite polarity signal. The output of transistor 122 goes to transistor 114 which makes the signal digital or on-and-off in character, and the output of transistor 114 goes to transistor 116 which serves as a power transistor. It supplies transformer T1 which is connected to the gate of silicon controlled rectifier 108.

If the polarity of the signal from the summing amplifier 98 is of opposite polarity or negative, it provides an output from transistor 124, which is supplied through a transistor 126 to transistor 118, which acts as an AND gate and corresponds in function to transistor 114. The transistor 126 is interposed in this case in order to change from negative to positive polarity. The signal from transistor 118 drives power transistor 120 which through transformer T2 controls the supply of the double frequency from the source 112 to the gate of the silicon controlled rectifier 110, and so controls the supply of power half waves from the power source to the armature of the servo motor 70.

It should be noted that there is a rate feedback loop at 128. Capacitor 129 acts as a bypass or filter capacitor. Thus there is a DC feedback from motor 70 applied to the correction signal, and the effect of this may be varied by a resistor 130. The feedback is from the armature of motor 70, and helps make the control linear in character.

With this arrangement the double frequency pulse is applied to the gate of one silicon controlled rectifier or the other in order to supply a train of substantially full width alternate and therefore unidirectional half waves, to drive the motor 70. The feedback loop 128 results in a motor speed which is proportional to the magnitude of the error, and regardless of the torque load.

The servo correction motor 70 turns the cage of the differential gearbox (54 in FIG. 1). The motor is linear,

and turns in only one direction. It turns rapidly for "retard," and slowly in the same direction for "advance." ("Retard" requires increased web tension to increase the repeat length, and vice versa for "advance.") The speed of the motor is dependent on the tension required to hold registration, and also on the speed of the press as described later. The motor is pulsed through the silicon controlled rectifiers during alternate  $\frac{1}{2}$  waves of the AC supply, and the back E.M.F. of the motor is compared to the correction voltage at 102 during the non-energized  $\frac{1}{2}$  waves of the AC supply. In this manner, the motor is utilized as a power device, while serving also as a generator which feeds back a signal representing the armature speed. When the armature feed back on line 128 equals the correction voltage at point 102, the silicon controlled rectifiers are pulsed only when necessary to maintain proper speed.

As so far described, the system is generally like that described in the copending application Ser. No. 599,929, with particular reference to its FIG. 12. This applies here to the upper half of FIG. 2, while circuitry for the present improvement limiting the range of variation of web tension is shown in the lower half of FIG. 2. We provide a roller 18 fitted with strain gauges or tension transducers marked 86. The particular transducers here used are roll bearing supports manufactured by Kidder Press Co., Inc., of Dover, N.H. The supports are secured in a fixed frame, and include two strain gauges in the bearing support at each end of the roll, one acting in compression and the other in tension, and these four are connected in bridge form as shown by the resistance bridge 86 at the lower left portion of FIG. 2. The roller 18 is schematically represented above the bridge 86.

In the system here illustrated the servo motor 70 preferably runs in one direction, but electrically the system is the same as a bidirectional system, because the electrical supply is fed in either direction, and when fed in the reverse direction, it provides for a rapid slowdown of the motor when going from a higher speed to a lower speed. In other words, the power flow is bidirectional, and in the slowdown periods, the motor acts as a generator which feeds power to the line, but this feed is through the other one of the two silicon controlled rectifiers 108 and 110. (It is not the rate feedback on loop 128 which comes from the intermediate half cycles.)

The bridge 86 is energized from an AC 110 volt supply shown at 132, which is stepped down to 6 volts by means of a transformer 134, the secondary of which has a center tap. The output of bridge 86 is a function of the web tension, and provides a signal on two conductors connected to two summing resistors 136. A potentiometer 138 may be varied for zero adjustment, to compensate for the weight of the roller 18 and for tolerance in the components. It is connected through a summing resistor 139. The signals are combined at 140 and are supplied to a summing amplifier 142 which again may be a Fairchild type 709 operational amplifier. It is connected through resistor 144 as a feedback amplifier.

Because the web being handled may have widths of say 15, 30, 45 or 60 inches, the total web tension differs proportionally in each case, and this is taken care of by a switch 146 which selects one or another of four different resistors 148, depending on the web width, the smaller resistor corresponding to smaller web width. These resistors may be made adjustable for preliminary adjustment, but then may be left fixed during normal use of the apparatus. The resistors 148 are in the feedback loop, and in combination with the resistor 144 they select the proper gain of the amplifier depending on the width of the web. The output at 150 is an AC voltage which is proportional to pounds per linear inch at the web.

This AC signal is changed to DC in a demodulator 152. The capacitance 154 in combination with a resistor 156 acts as a filter. The DC signal operates an ammeter 158 through a resistor 160, and this meter preferably has a

scale in terms of web tension in pounds per inch of web width.

This has a particular practical advantage in that the operator can read the tension to which the web is being subjected to hold register, and if the tension remains consistently high, say 3 pounds or more per inch of web width, he can arrange to have the plate cylinder "shaved" to slightly reduce its diameter, so that the normal web tension will be lowered to a more desirable figure of say  $1\frac{1}{2}$  pounds per inch of web width. With the web running at high tension, there is little range left available for a retard correction, and such a correction may take longer than would be necessary if the web were running at lower web tension. Thus there would be more waste or discarded web when starting up.

For this purpose the meter preferably has a second scale paralleling the first scale, and showing the amount (in thousandths of an inch) the plate cylinder should be shaved to achieve an optimum tension level (say  $1\frac{1}{2}$  pounds per inch of web length for newsprint). If the web tension runs consistently low, say  $\frac{1}{2}$  lb. per inch of web width, the plate cylinder may be "packed" or shimmed to increase its effective diameter so that the normal web tension will be raised to the more desirable level of say  $1\frac{1}{2}$  pounds per inch of web width.

The lower tension limit is adjusted by means of a potentiometer 162, and the upper limit is adjusted by means of a potentiometer 164. There is a 12 volt supply at 166, through voltage dropping resistors 168, and the combination of resistor and potentiometer 162 acts as a voltage divider.

An operational amplifier 170 (e.g. Fairchild Type 709) compares the voltage at 172 (representing the low voltage limit corresponding to the desired low tension limit) with the voltage at 174 which is proportional to the actual web tension in pounds per linear inch. When the voltage at 174 is greater than the voltage at 172, the output of the amplifier 170 at 176 is a negative voltage, typically minus 12 volts. The voltage on the diode 178 at 180 is clamped to ground at minus 0.6 volt, this being the forward breakdown voltage of silicon diode 178.

If however, the voltage at 174 is less than the voltage at 172, because the web tension is less than the desired low limit, the output voltage of the amplifier 170 at 176 is a positive voltage proportional to the difference between the two input voltages. The voltage at point 180 then is positive and feeds through line 182 and summing resistor 183 to combine with the error voltage at 184. This positive voltage will drive the servo motor 70 slower to increase the web tension above the lower limit.

The resistor 186 is a feedback resistor which reduces the gain of amplifier 170, so that the output at 176 is proportional to the difference between the inputs. This is done so that the feedback action is not too abrupt and does not cause hunting or unstable condition.

Coming now to the "high limit" part of the diagram, the amplifier 188 again is an operational amplifier (e.g. Fairchild Type 709). Point 190 is at a potential representing the high tension limit, say four pounds per linear inch. When the voltage at 174 representing actual web tension is lower than that at 190, the amplifier output at 192 is positive, and typically would be at the saturation voltage of the amplifier, say plus 12 volts. However, the voltage at the point 194 is clamped at plus 0.6 volt representing the forward breakdown voltage of the silicon diode 196.

If the voltage at 174 representing the actual web tension exceeds the limit voltage at 190, the output of the amplifier at point 192 goes negative, thereby providing a negative voltage at the point 194, and through summing resistor 183, provides a negative voltage at the point 184. This negative voltage is in proper direction to slow down the motor 70, thereby reducing the web tension to a level approximately equal to the high web tension limit as set at point 190.

The two resistors 198 are employed to prevent excessive current being drawn through the diodes 178 and 196 when the web tension is properly located between the low and high limits. The two resistors 200 are used to isolate the two outputs applied to resistor 183 because it is impossible to be at the low and high limit simultaneously.

When the web tension is between the desired limits, the voltage at point 180 is minus 0.6 volt, and the voltage at the point 194 is plus 0.6 volt. The output going to resistor 183 is therefore zero, the resistors 200 having the same value. The tension limits and the described circuitry in the lower half of FIG. 2 therefore have no effect on the normal registration control of the motor 70, as long as the web tension is at a value between the predetermined low and high limits. The web tension is freely varied between the low and high limits as needed for registry by the circuitry in the upper half of FIG. 2, without interference from the circuitry in the lower half of FIG. 2.

With reference to FIG. 1 it will be recalled that the main drive of the draw roll 18 is from the main drive shaft 50, and that the servo motor 70 supplies only a slight correction. The amount of this correction (the servo motor correction) is preferably kept in proportion to the press or web speed. Thus, if the press speed were doubled from say 500 feet per minute to 1000 feet per minute, the servo motor 70 should double its speed range in order to remain in proportion. Circuitry for this purpose is shown in the lower right-hand corner of FIG. 2.

Reverting to FIG. 2 there is a tachometer 202 which is driven by the main drive shaft. The output of tachometer 202 is in volts per thousand feet of web speed per minute, and is applied to an operational amplifier 204 (e.g. Fairchild Type 709). It is supplied through a resistor 206, and the output is connected to a lamp 208 which excites two cadmium sulphide photoconductive resistors 210 and 212. These two resistors are so positioned relative to the lamp 208 that their values in ohms are a logarithmic function of the lamp excitation voltage.

The resistor 210 is energized from a minus 12 volt supply, and is summed to the plus input from the tachometer by the operational amplifier 204, as shown by the connection 214. The difference, if any, is amplified in the amplifier 204, which acts as a high gain amplifier. The excitation of the lamp 208 is made logarithmic, and provides a linear relationship between the photoconductive resistor 210 and the tachometer voltage. The two photoconductive resistors 210 and 212 are selected to be alike, say within 5% of each other, and therefore the resistor 212 remains within 5% of the resistor 210 throughout the entire web speed range as determined by the tachometer 202.

The assembly of the lamp and photoconductive resistors shown in the broken line rectangle 216 is a commercially available unit Model No. 1033-2 manufactured by National Semiconductor, Inc. of Montreal, Canada.

Initially, when the printing press is just starting up and operating at low speed, the resistance value of the resistor 212 is very high compared to that of the resistor 131. As the press increases in speed, the resistor 212 decreases in value, thereby providing a smaller feedback voltage from the armature of the servo motor 70 at the point 218. The resistor 130 is much larger than the resistor 131. The voltage at 218 is summed through resistor 130 at point 184, and the voltage difference from the correction voltage drives the silicon controlled rectifiers (one or the other). As the press speed increases the motor 70 is allowed to run faster for the same feedback voltage at the point 184. The photoconductive resistor 212 and the resistor 131 act as a voltage divider network at the point 218, which divider is approximately linear for all press speeds above a very low initial press speed.

With automatic splicing, to be described later, the splicing operation constitutes an abrupt change or departure from registration, and an additional circuit refinement may be provided to accelerate the response to that change.

For this purpose an operational amplifier 220 (e.g. Fairchild Type 709) and an integrator 222 may be added, but the use of these components is an optional refinement and is not essential. This combination provides at point 224 a signal which is proportional to the rate of change in the error signal. The rate of change error signal is provided at 224 because the output of amplifier 220 is fed to the input of the integrator 222, and its output is fed back on line 228 to the amplifier 220. Thus a rapidly changing error which occurs at the time of splicing, causes a higher input voltage on line 226 to the summing amplifier 98.

Initially the error signal at 94 is transmitted directly through the amplifier 220 and arrives on line 226 as an input to the summing amplifier 98. A short time later the output of integrator 222 subtracts from the error signal at the input to amplifier 220. Some time later the output of the integrator 222 equals the voltage at the input to amplifier 220, thus providing zero effect at point 224. The time constant of the integrator 222 can be adjusted to provide the aforesaid unusually large correction for a short time duration, in order to more rapidly correct the registration error when splicing, so as not to have the output of the main integrator 96 driven excessively far from its normal condition. The voltage on line 228 subtracts from the voltage on line 94, and can never provide more than neutralization of voltage at the input to amplifier 220, and therefore the effect of the added components 220 and 222 is eliminated after a brief time. Thereafter the normal operation makes use of only the integrator 96 and the operational amplifier 98 as described in the aforesaid copending application Ser. No. 599,929.

The splice of a new paper roll to an expiring roll may be performed manually with shut down, but in preferred form the splice is made automatically at full web speed. For this purpose, the paper roll shown at 12 in FIG. 1 is mounted on any suitable turnover stand, and referring to FIG. 5, this is suggested by roll 12 which is an expiring roll, and a new roll 230, these being carried on turnover arms 232 rotated at 234. Turnover stands are well known and require no detailed description. Many have three arms 120° apart, instead of two as here shown. Apparatus with two arms is described for example in U.S. Pat. 3,195,827, issued July 20, 1965, and entitled "Splicer for Moving Web."

The splicing should provide registration of the print on the new web to that on the expiring web, and this requires preparation of the new paper roll.

Referring to FIG. 3, the new roll 230 has a position arrow 236 which is extended by means of a line 238 for positioning in some types of reel stand. A register mark ahead of the line 238 is located as shown at 240. The end is trimmed to V shape as shown at 242, and adhered with an adhesive tab 244. A band 246 is marked to represent an area for contact with a speed-up belt which brings the new roll up to web speed before splicing is attempted.

A flexible steel marking gauge 248 is bent around the roll from the line 240 and corresponds to a desired number of repeat lengths of the preprint material, say three repeat lengths, thus arriving at the mark 250 in FIG. 3A. A tab of reflective tape is applied to the end of the roll as shown at 252. It is preferably a commercially available retro-reflective tape, an example being that made by Minnesota Mining and Manufacturing, Inc. (or "3M") of St. Paul, Minn., and identified as their Scotch Light Reflective Sheeting No. 3270, with pressure sensitive adhesive back. Adhesive is applied to the outer end of the roll as suggested at 254, but the band 246 is left clear for the speed-up belt.

Referring now to FIG. 5, the end of the roll 230 is scanned by a retroreflective scanner 256, and responds to passage of the retroreflective tab 252. The resulting pulse is applied to an AND gate 258.

At the same time the preprint on the expiring web 260 is scanned by a web scanner 262. The web 260 is normally

clear of the new roll **230**, but may be pressed against the new roll at the instant of splice, as by means of a brush **264** forming a part of the splicing apparatus. The said apparatus also includes a knife **266** which operates after the splice is effected. (The direction of rotation in FIG. 5 is opposite the direction of rotation indicated in FIGS. 3 and 3A). The measure **248** (FIG. 3) provides delay for movement of the brush **264**.

The signal from the web scanner **262** consists of a series of pulses, one for each registration mark or repeat length, as indicated in the upper part of FIG. 4 marked "WEB SIGNALS." The pulses from the roll scanner **256** are spaced much further apart, as indicated by the lower part of FIG. 4 marked "ROLL SIGNALS." Inasmuch as the number of repeat lengths on the roll circumference is ordinarily an odd amount, there will be registration of the pre-printed matter at intervals where the pulses coincide, as indicated by the pulses **268** and **270** in FIG. 4.

The retroreflective arrangement is schematically indicated in FIG. 6. The light source is schematically shown at **272**, and the light passes through a half silvered mirror **274** to a lens system **276** which projects light against the end **278** of the new roll **230**. The reflection from the retroreflective tape is back through the same lens system **276** to the half silvered mirror **274**, and excites a photocell **280**. The retroreflective tape reflects only light perpendicular to the end of the roll. This arrangement gives a strong signal without background interference, despite the somewhat irregular nature of the roll end, and the existence of some wobble in spacing between the scanner and the roll end.

The width of the retroreflective tab **252** may be used as a measure of tolerance in the splicing operation. Thus, if the splice tolerance is plus or minus one inch, the tab is made two inches in width in circumferential direction.

When the operator sees the expiring roll **12** becoming small, and having already prepared the new roll for splicing, he presses a "start" button forming a part of the splicer apparatus, and not shown in FIG. 5. In some cases this causes turnover at the reel stand until the new roll is in splicing position, at which time the speed-up belt operates automatically. In other cases the turnover of the reel stand is separately controlled, and the "start" button starts operation of the speedup belt to bring the new roll up to web speed. In either case, when the expiring roll has nearly expired the operator presses a "paster" or "splice" button, shown at **281** in FIG. 5, and this sets the output state of the flip-flop or bistable element **282** at high level, and an output is led through conductor **284** to the AND gate **258**. The element **282** acts as a holding relay so that the button **281** does not have to be held down.

The pulses from the web scanner **262** are delayed in a delay circuit **286** to compensate for the location of the web scanner **262**, which is not at the splicing point. It also has a ten turn potentiometer **288** for very fine adjustment of the amount of time delay. The tachometer **202** (which corresponds to the tachometer **202** in FIG. 2) adjusts the time delay in unit **286** automatically, because the delay must be related to web speed, that is, it must be compensated for web speed in order to represent web length rather than time delay.

As soon as there is a coincidence of pulses, as shown at **268**, **270** in FIG. 4, corresponding to proper registration, there is a signal which passes through the AND gate **258** and the conductor **292**, which actuates a one-shot multivibrator **294**, which in turn energizes a relay **296** which serves to actuate the splicing brush **264** previously mentioned.

The signal from one shot **294** is supplied through line **298** to another delay circuit **300**. This delay circuit is also compensated for web speed, as is indicated by the connection **302** to the tachometer **202**. The delay in circuit **300** is much greater, and covers the web length all the way from the splicing brush to the folder. This may

be highly variable, say anywhere from three to eight seconds, depending on the particular printing press layout, and the distance of the folder from the splicing point. Adjustment of the delay is indicated by the variable resistor **304**, but this remains fixed once it has been adjusted for a particular printing plant.

The relay **306** is energized, for the duration of the delay in **300**, and reverting briefly to FIG. 2, this corresponds to opening of the switch **106** which is the relay contacts. This would tend to stop the servo motor **70**, but because of the limit arrangement provided by the circuitry in the lower half of FIG. 2, the servo motor drops to a speed corresponding to the low web tension limit. The motor **70** continues to run at that speed which reduces the web tension to the desired minimum of say  $\frac{1}{2}$  pound per linear inch, and thereby guards against breaking the newly made splice.

This requires a fast slowdown because the motor ordinarily would be applying a tension above  $1\frac{1}{2}$  pounds per inch, and the feed of reverse pulses of power supply through the reverse silicon controlled rectifier helps produce the desired fast slowdown.

Reverting to FIG. 5, the knife **266** is actuated a little later than the brush **264**, to make sure that the adhesive area is already pressed against the expiring web before the tail of the expiring web is cut off. This knife delay is obtained as a part of the usual and known splicing equipments.

The reduced web tension to protect the splice is maintained until the time of delay circuit **300** runs out.

To reset the circuitry of FIG. 5, and more specifically the flip-flop **282**, an output pulse of the one shot **294** not only works the relay **296**, but also sends a signal on a line **308** back to the reset terminal of the flip-flop **282**.

The delay circuits in rectangles **286** and **300** need not be described in detail, because known delay circuits may be used.

The departure from registration caused by splicing is quickly rectified, say in fifty repeat lengths, and in newspaper work this is acceptable, there being no need to discard the newspapers in question. Moreover, the adjustment at **288** can be made to allow say one inch for the change in register caused by the abrupt drop in web tension when splicing, caused by opening of contacts **106**.

It will be understood that the operator later removes the expired roll with its severed tail from the turnover arms. A new roll is added and is prepared as previously described in connection with FIGS. 3 and 3A. It is shifted to splicing position. The operator starts the speed-up of the new roll, or it may start automatically with turnover, and in due course the operator presses the "paster" button to initiate the splicing cycle. An actual splice takes place automatically as soon as the printed matter on the two webs are in registration. The turnover arms shown in FIG. 5 are not drawn to scale, and in actual apparatus the arms may be rotated without interference. In many stands there are three arms rather than two as here shown.

The present inserter controls the registration of a fully or partially preprinted web, to a printing unit or folder or any high-speed web-fed machinery, by controlling the feed of the web through a set of rubber-to-steel infeed draw rollers. The equipment may be used with letterpress, offset, or rotogravure, and is independent of the nature of the roll stand or tension system fitted to the particular press. The preprint used can be produced on one machine, and inset into the same or another type of machine. For example, letterpress preprint can be inset into letterpress machines to increase paging or to introduce run-of-press color; or alternatively, high quality color rolls can be produced by offset, rotogravure or magazine letterpress, and inset into letterpress, newspaper presses, or other web-fed machinery. Various other combinations are possible. The web tension can be produced in other ways than by a draw roll, although that is preferred.

The use of a correction signal which combines both

a proportional error signal and an integrated signal (provided by the components 96 and 98 in FIG. 2) has a number of advantages. The integrated signal is relatively large, and makes possible the use of a low gain and therefore stable system. The proportional error signal decreases with correction, and so tends to offset the growth of the integrated signal, but the amount of decrease is slowed down, which helps avoid instability. The integrated signal alone is not sensitive to a sudden change, but the proportional error signal does respond. Because of the integrated signal the error signal is driven to approach zero, because the integration continues as long as an error signal is present. The integral channel looks like a high gain loop for errors which occur very gradually. It helps take care of a cumulative error, and when working with a preprinted web a repeat length variation is a cumulative error. Because of the difficulty of introducing mechanical drives on a variety of different printing presses, a Selsyn drive is used between the gear box and the draw roller, which gives flexibility for installation.

It is believed that the construction and operation of our improved inserter and splicer for a preprinted web, as well as the advantages thereof, will be apparent from the foregoing detailed description. It will also be apparent that while we have shown and described the improvement in preferred form, changes may be made without departing from the scope of the invention, as sought to be defined in the following claims.

We claim:

1. In the operation of a system operating on a preprinted web, and providing registration as to the preprinted matter, the method which includes scanning the web to detect a registration error, raising or lowering the tension on the preprinted web in response to detection of an error to so increase or decrease the repeat length as to tend to maintain registration, continuously measuring the resulting web tension, limiting any increase in resulting web tension to a predetermined desired high limit which is less than that which may break the web, and limiting any decrease in resulting web tension to a predetermined desired low limit which is high enough to prevent "wandering" of the web.

2. A method as defined in claim 1, which includes feeding the web between a metal draw roll and a rubber roll, driving the draw roll at a speed approximating the desired web speed, and feeding in a variable correction to slightly vary the speed of the draw roll to provide a desired web tension which is between the predetermined lower and upper limits of web tension.

3. A method as defined in claim 2, which includes splicing a new web to an expiring web without stopping the expiring web, automatically reducing the web tension to the lower limit of web tension during the splicing operation and until the splice leaves the system so that it is no longer under breaking tension, in order to prevent breaking at the splice, and restoring normal web tension between the limit values as needed for registration after the splice has moved out of the system where it is under tension.

4. A method as defined in claim 3, which includes applying a tab of retroreflective tape to the end of the new roll in a desired location relative to the preprint on the new web, bringing the new roll up to approximate web speed, and scanning the end of the new roll by means of a retroreflective scanner for purposes of securing registration of the preprint on the expiring and new webs when splicing.

5. A method as defined in claim 4, which includes making the width of the retroreflective tape correspond to the plus and minus tolerance desired for the splicing operation.

6. A method as defined in claim 1, which includes splicing a new web to an expiring web without stopping the expiring web, automatically reducing the web tension to the lower limit of web tension during the splicing operation and until the splice leaves the system so that

it is no longer under breaking tension, in order to prevent breaking at the splice, and restoring normal web tension between the limit values as needed for registration after the splice has moved out of the system where it is under tension.

7. A method as defined in claim 1, which includes applying a tab of retroreflective tape to the end of the new roll in a desired location relative to the preprint on the new web, bringing the new roll up to approximate web speed, and scanning the end of the new roll by means of a retroreflective scanner for purposes of securing registration of the preprint on the expiring and new webs when splicing.

8. A method as defined in claim 7, which includes making the width of the retroreflective tape correspond to the plus and minus tolerance desired for the splicing operation.

9. A system for operating on a preprinted web in registration with the preprinted matter on the web, said system comprising means for scanning the web to detect an error in registration, web tension means responsive to said scanning means for raising or lowering the tension on the preprinted web to so increase or decrease the repeat length as to maintain registration, transducer means to continuously measure the resulting web tension, and means effective to maintain the resulting tension below a predetermined upper limit and above a predetermined lower limit while said web tension means raises or lowers the registration tension of said web between said upper limit and said lower limit in response to the error sensed by said scanning means.

10. A system as defined in claim 9, in which the means to vary the tension on the preprinted web comprises a metal draw roll and a rubber roll between which the web is squeezed, means for driving the draw roll at a speed approximating the desired web speed, and means including a correction motor and a 360 degree continuous running register of the differential gear type for feeding in a variable speed correction to slightly vary the speed of the draw roll to provide a desired web tension which is between the predetermined lower and upper limits of web tension.

11. A system as defined in claim 9, in which there is means effective to set the upper limit of web tension at a value which is less than that which would break the web, and means effective to set the lower limit of web tension at a value which is high enough to prevent "wandering" of the web.

12. A system as defined in claim 11, which includes means for splicing a new web to an expiring web without stopping the expiring web, means to automatically reduce the web tension to the lower limit of web tension during the splicing operation and until the splice leaves the system so that it is no longer under breaking tension, and a delay means the running out of which restores normal web tension between the limit values and as needed for registration.

13. A system as defined in claim 12, which includes a tab of retroreflective tape adhered to one end of the new roll in a desired location relative to the preprint on the outer end portion of the new web, means to bring the new roll up to approximate web speed preparatory to splicing, a retroreflective scanner at the end of the new roll for response to the retroreflective tape, and means controlled by said scanner for so timing the operation of the splicing mechanism as to secure registration of the preprinted matter on the expiring and new webs when splicing.

14. A system as defined in claim 13, in which the width of the retroreflective tape corresponds to the plus and minus tolerance desired for the splicing operation.

15. A system as defined in claim 11, in which the change in web tension is produced by a correction signal, and in which the scanning means produces a proportional error signal, and in which there is an integrator to inte-

13

grate the proportional error signal to produce an integrated signal, and a summing amplifier to sum the proportional error signal and the integrated signal to thereby provide the aforesaid correction signal which is used for correcting the web tension.

16. A system as defined in claim 12, in which there are additional means to accelerate the response to the rapidly changing error signal caused when the web tension is reduced to the lower limit of web tension during the splicing operation.

17. A system as defined in claim 15, in which there are additional means to accelerate the response to the rapidly changing error signal caused when the web tension is reduced to the lower limit of web tension during the splicing operation.

18. A system as defined in claim 12, in which there is a means which is adjustable to change the timing of the splice to compensate for reduction in web tension to the lower limit of web tension.

19. A system as defined in claim 11, in which the change in web tension is produced by a correction motor having a utilized range of motor speed, a tachometer responsive to the web speed, and means whereby the utilized range of correction speed of the correction motor is varied in response to the tachometer in order to keep the same proportional to the web speed.

20. A system as defined in claim 11, in which the transducer means is a strain gauge.

21. A system as defined in claim 11, in which there are additional means to adjust the values of the high and low web tension limits.

22. A system as defined in claim 11, in which there are additional means to adjust for different widths of web, so that the tension limits are in relation to units of web length.

23. A system as defined in claim 11, in which the means operating on the preprinted web is a printing cylinder, and in which there is additional electrical circuitry including a meter having a scale showing actual web tension in pounds per inch of web width and another scale showing the change in print cylinder diameter needed for the printing cylinder operating on the web to establish a desired optimum web tension.

24. A system as defined in claim 9 in which said limiting means includes means effective to set the upper limit of web tension at a value less than that which would break the web.

25. A system as defined in claim 9, in which said tension limiting means includes means effective to set the lower limit of web tension at a value which is high enough to prevent "wandering" of the web.

26. A system as defined in claim 25, which includes means for splicing a new web to an expiring web without stopping the expiring web, means to automatically reduce the web tension to the lower limit of web tension during the splicing operation and until the splice leaves the system so that it is no longer under breaking tension, and means to restore normal web tension between the limit values and as needed for registration after the splice leaves the system.

27. A system as defined in claim 19 in which the tachometer develops a voltage, and in which there is apparatus to produce a variable resistance which varies in linear proportion to the said variable voltage, said apparatus comprising a lamp, a first photoconductive means illuminated thereby, a second photoconductive means also illuminated thereby, an amplifier to amplify said variable voltage and to apply the same to the lamp to excite the lamp, a feedback connection from one of said photoconductive means to the amplifier, the second conductive means being used as a variable resistor, the feedback from the first photoconductive means to the amplifier being such as to obtain a variable lamp excitation which results in a linear change in the resistance of the second photoconductive means relative to

14

the initial input voltage, said second photoconductive means being connected into the control circuit of a servo motor which changes the web tension produced by the web tension means.

28. A system as defined in claim 9, in which the means operating on the preprinted web is a printing cylinder, and in which there is additional electrical circuitry including a meter having a scale showing actual web tension in pounds per inch of web width.

29. A system as defined in claim 9, in which the means operating on the preprinted web is a printing cylinder, and in which there is additional electrical circuitry including a meter having a scale showing the change in print cylinder diameter needed in the printing cylinder operating on the web to establish a desired optimum web tension.

30. Apparatus to produce a variable resistance which varies in linear proportion to a variable voltage, said apparatus comprising a lamp, a first photoconductive means illuminated thereby, a second photoconductive means also illuminated thereby, an amplifier to amplify said variable voltage and to apply the same to the lamp, to excite the lamp a feedback connection from one of said photoconductive means to the amplifier, the second photoconductive means being used as a variable resistor which is unconnected to the remainder of the apparatus, and which is therefore available for use in other circuitry, the feedback from the first photoconductive means to the amplifier being such as to obtain a variable lamp excitation which results in a linear change in the resistance of the second photoconductive means relative to the initial input voltage.

31. Apparatus as defined in claim 30, in which the characteristic curve of one photoconductive means showing resistance relative to lamp excitation, is matched to and is substantially the same as the corresponding characteristic curve of the second photocell.

32. A system for handling a web, said system comprising means to measure and compare the web tension with a desired web tension and to provide a proportional tension error signal, means to integrate the proportional error signal to provide an integral error signal, means responsive to the rate-of-change of the proportional error signal to provide a rate-of-change signal, means to sum the proportional error signal and the integral error signal and the rate-of-change signal to provide a correction signal, means to vary the web tension, and a correction motor responsive to said correction signal to appropriately adjust the said tension varying means in that direction which helps restore the desired web tension.

33. A system as defined in claim 32, in which the correction motor has a utilized range of motor speed, a tachometer responsive to the actual web speed, and means whereby the utilized range of correction speed of the correction motor is varied in response to the tachometer in order to keep the same generally proportional to the web speed.

34. A system as defined in claim 33, in which the tachometer develops a voltage, and in which there is apparatus to produce a variable resistance which varies in linear proportion to the said variable voltage, said apparatus comprising a lamp, a first photoconductive means illuminated thereby, a second photoconductive means also illuminated thereby, an amplifier to amplify said variable voltage and to apply the same to the lamp to excite the lamp, a feedback connection from one of said photoconductive means to the amplifier, the second conductive means being used as a variable resistor, the feedback from the first photoconductive means to the amplifier being such as to obtain a variable lamp excitation which results in a linear change in the resistance of the second photoconductive means relative to the initial input voltage, said photoconductive means being connected into the control circuit of the said correction motor.

15

35. A system as defined in claim 32, in which the means to measure and compare the web tension includes a strain gauge applied to means carrying a roller engaging the web.

36. A system as defined in claim 32, in which there are additional means to compensate for different widths of web, so that the maintained web tension is in relation to units of web width. 5

37. A system as defined in claim 32, in which there is additional electrical circuitry including a meter having a scale showing actual web tension in units of force per unit of web width (e.g. pounds per inch). 10

38. A system as defined in claim 32, in which there is a web feed roll, and means including differential gearing to drive the feed roll at approximately correct web 15

16

speed, and in which the correction motor which is responsive to the correction signal feeds its correction into the said differential gearing.

#### References Cited

#### UNITED STATES PATENTS

|           |         |               |
|-----------|---------|---------------|
| 2,931,962 | 5/1960  | Huck.         |
| 3,032,245 | 5/1962  | George et al. |
| 3,112,052 | 11/1963 | Johnson.      |

ALLEN N. KNOWLES, Primary Examiner

U.S. Cl. X.R.

226—25, 30, 100