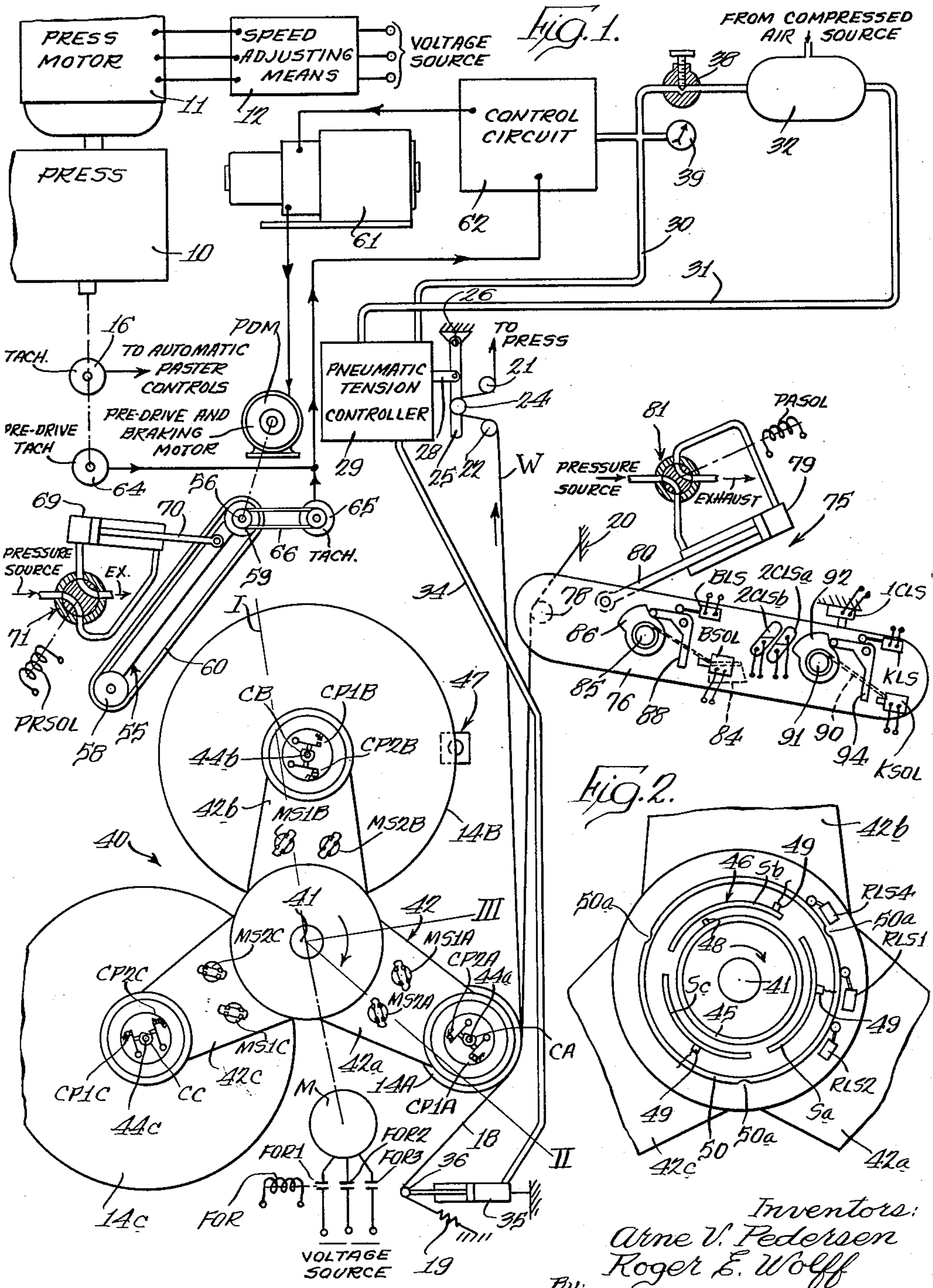
Dec. 6, 1960 A. V. PEDERSEN ET AL 2,963,235

AUTOMATIC WEB SPLICING APPARATUS

Filed June 11, 1957 5 Sheets-Sheet 1



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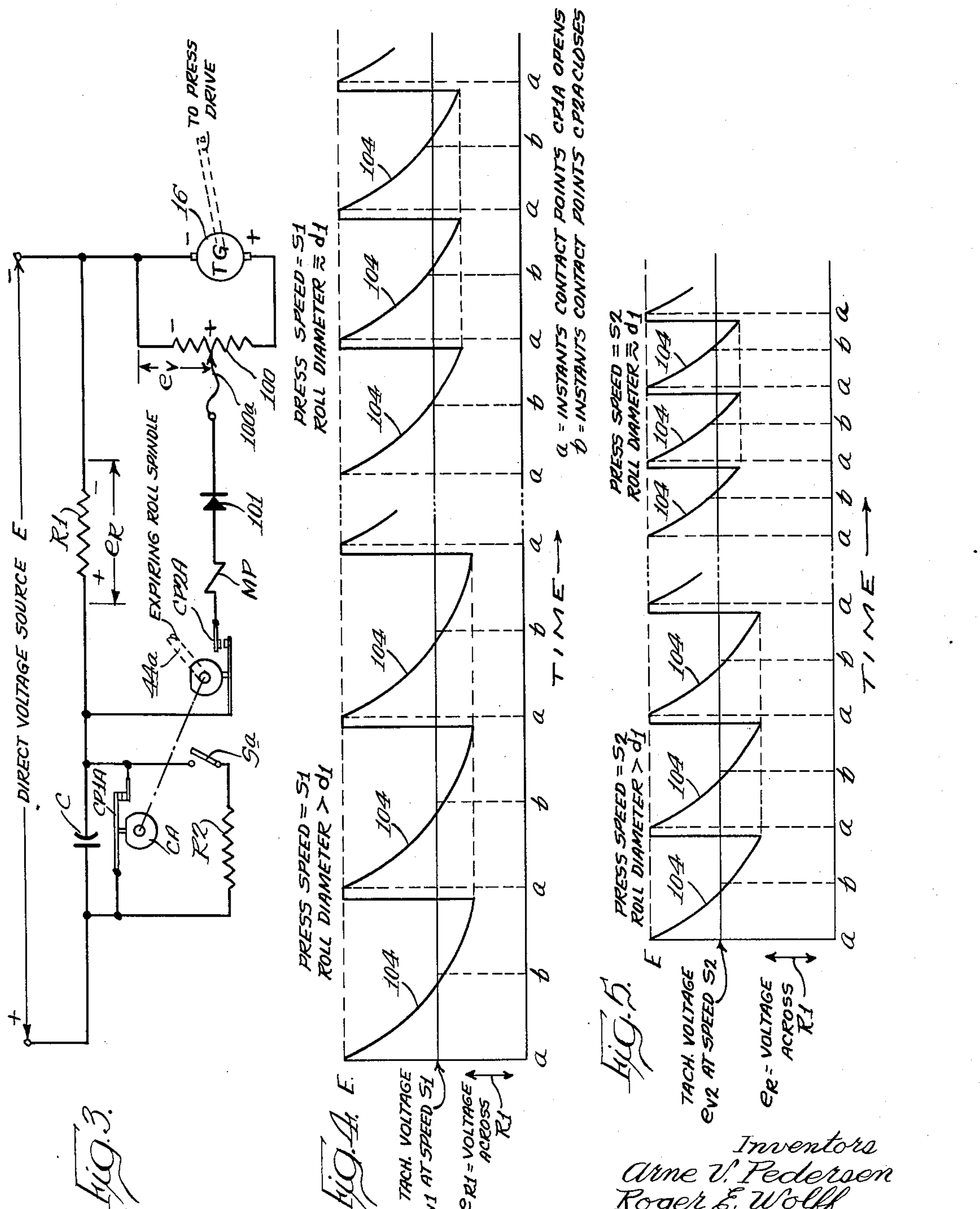

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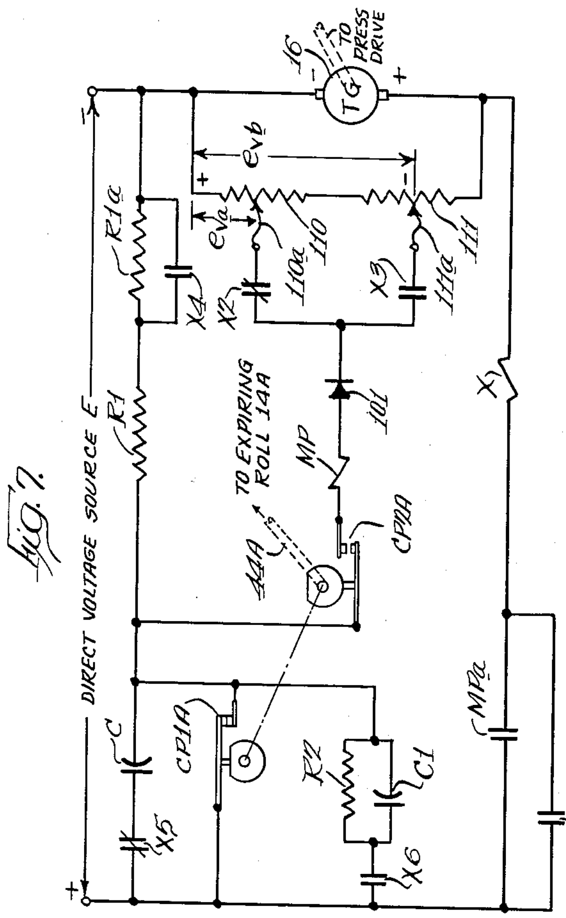

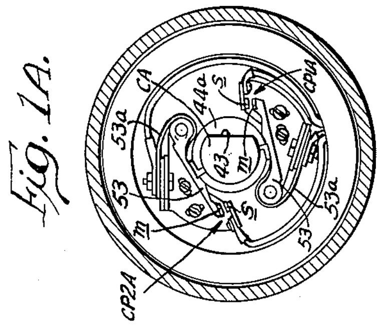

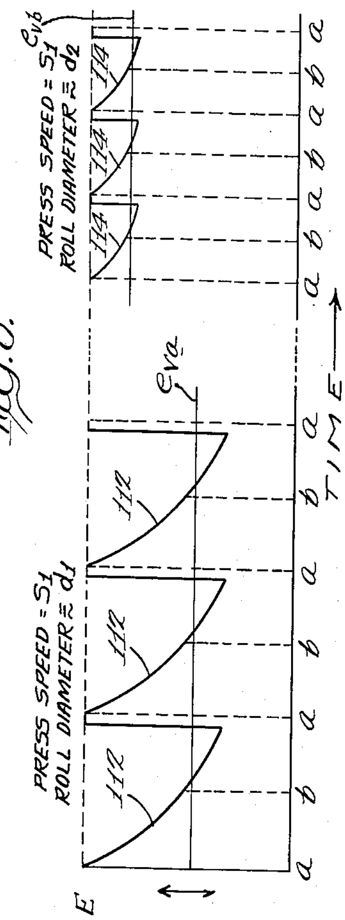

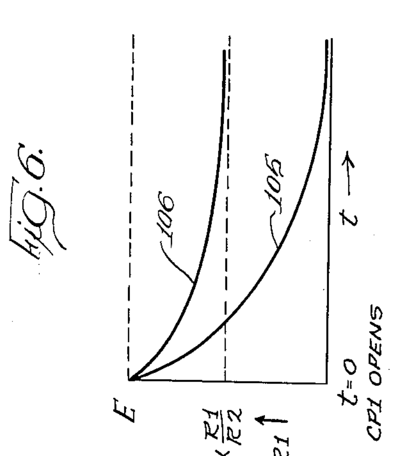

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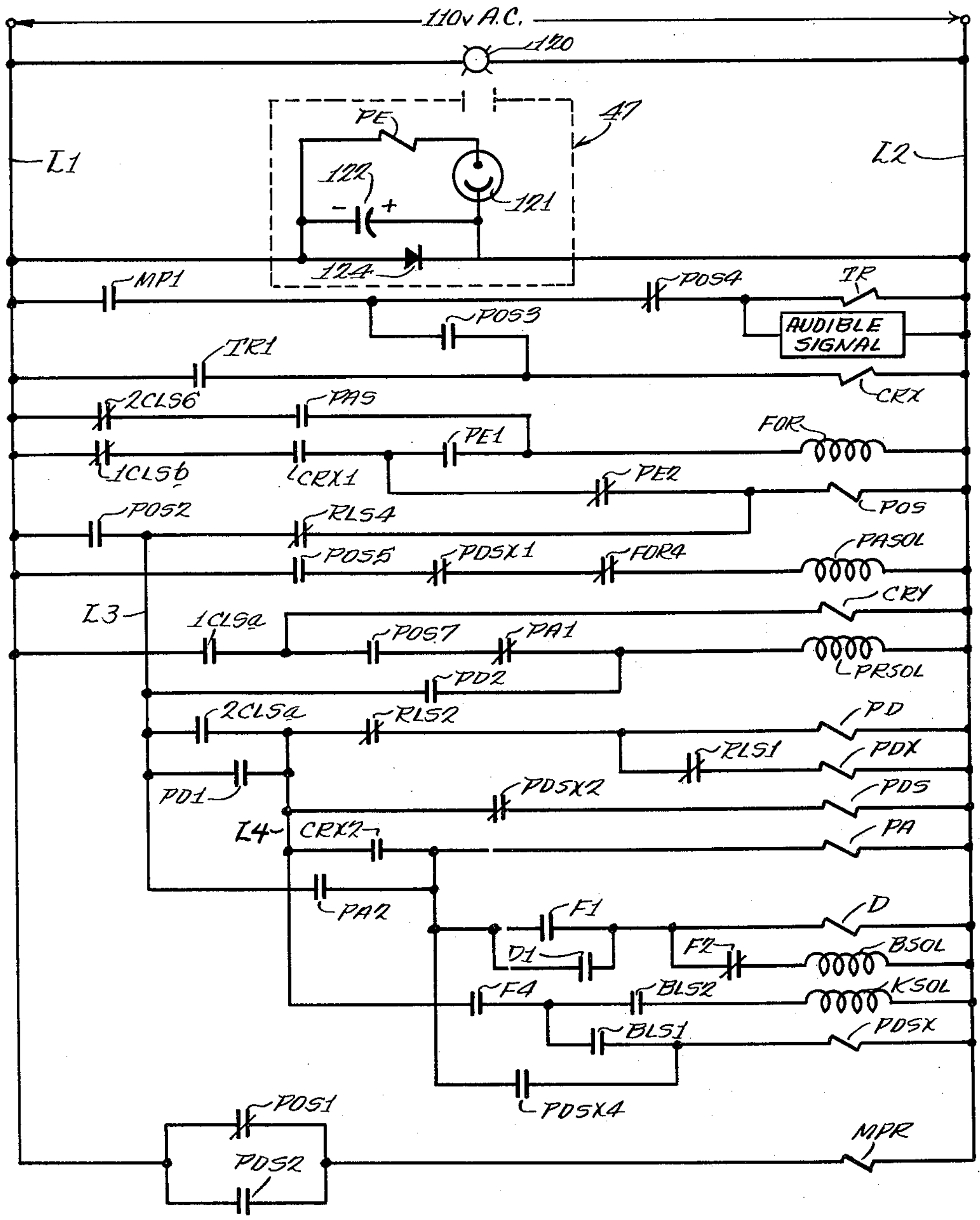

Fig. 9.

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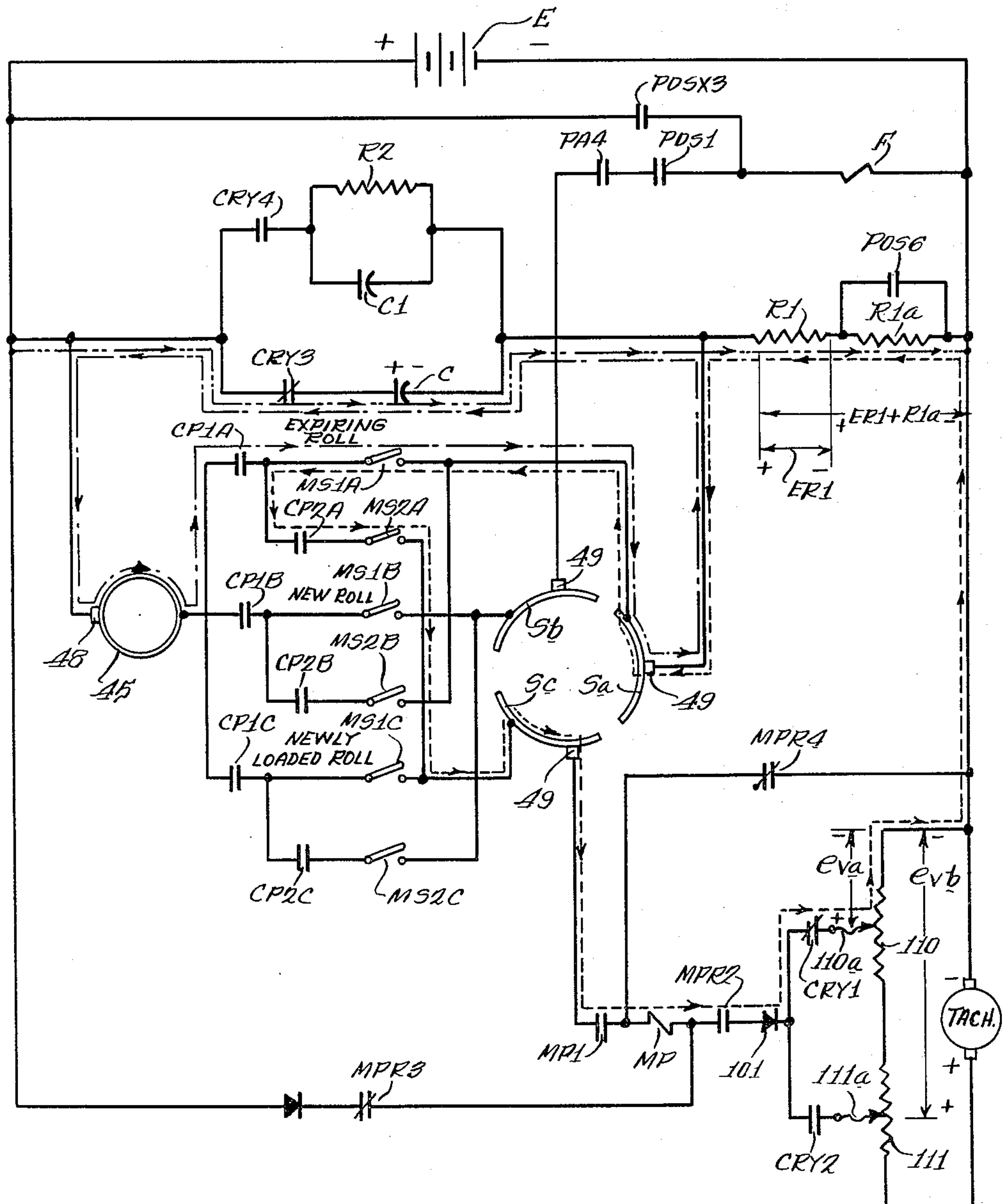

Fig. 9A.

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2,963,235

AUTOMATIC WEB SPLICING APPARATUS

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Filed June 11, 1957, Ser. No. 664,939

30 Claims. (Cl. 242—58.3)

The present invention relates in general to apparatus for making "flying pasters", i.e., for splicing a running web drawn from an expiring roll to the web of a new roll. While not limited thereto, the invention finds particularly advantageous use in web splicing apparatus for newspaper printing presses, where it is desirable to maintain high press speeds as an expiring roll of paper is replaced by a new roll without interrupting the travel of the paper web into the press.

A continuous paper web is drawn from a supply roll into a modern newspaper press at very high velocities. If in the use of web splicing apparatus the press attendant is called upon to judge the amount of paper left on an expiring roll, and to actuate controls for initiating the various steps or operations necessary to accomplish the web splicing, an error in timing of only a few seconds may result in missing the splice. That is, the tail end of the web from the expiring roll might run into the press without picking up the web from the new roll. If this happens, the press must be shut down and rethreaded before printing can be continued, resulting in a delay which is intolerable in modern newspaper practice where a premium is placed on reducing to an absolute minimum the time consumed between the writing of news copy in the newsroom and the appearance of that copy in print on the city streets. On the other hand, if the press attendant is extremely cautious, he may initiate the splicing operation too early and thus leave a substantial amount of expensive newsprint left on the old roll.

It is the general aim of the invention to make possible fully automatic web splicing operations, completely eliminating any control duties of an operator or attendant.

Coordinate with that aim is an object of the invention to automatically control web splicing operations such that the changeover from an expiring roll to a new roll reliably takes place before the tail of the expiring roll slips by, but not until substantially all of the web on the expiring roll has been consumed. This avoids "missing" splices and the consequent necessity of shutting down the web-consuming device or press; and yet it also assures maximum economy in using up nearly all of the web on a roll.

Another object of the invention is to automatically initiate preliminary operations, such as positioning and predriving the new roll and lowering predrive and paster carriages, a predetermined and substantially uniform time interval before the actual splicing must take place, thereby assuring that there will be sufficient time to complete such preliminary operations.

A further object of the invention is to automatically effect the actual splicing operation at an instant that the expiring roll is reduced to a predetermined small diameter, and regardless of the particular speed at which the press or web-consuming device is operating.

It is a related object of the invention to effect such automatic initiation of both the preliminary operations and the actual splicing operation in sequence, both properly timed in relation to the gradually diminishing diameter of the expiring roll, by two sensing means which are successively brought into play and both of which employ substantially the same components.

Still another object is to provide an improved and reliable system for sensing when a roll, upon which or from which a web is being wound or unwound, reaches a predetermined diameter, and even though the linear velocity at which the web travels may be varied over a wide range.

It is a further object to provide a system for sensing and determining an instant in time which marks the beginning of a predetermined time interval before such a roll reaches such a predetermined diameter, and regardless of the velocity at which the web is traveling.

Other objects and advantages will become apparent as the following description proceeds, taken in conjunction with the accompanying drawings, in which:

Figure 1 is a schematic illustration of web splicing apparatus utilizing the features of the present invention;

Fig. 1A is a detail view of contact points actuated by a cam on a roll spindle;

Fig. 2 is a fragmentary, diagrammatic view of a portion of the roll-supporting reel, illustrating the cams, slip rings, and brushes associated therewith for control purposes;

Fig. 3 is a schematic wiring diagram of means for sensing and signaling when a web roll reaches a predetermined diameter;

Figs. 4 and 5 are graphic representations of voltage variations during the operation of the circuitry in Fig. 3 with the press speed or linear velocity of the web at relatively low and high values, respectively;

Fig. 6 is a graphic comparison of two decaying voltages obtained by different circuit conditions in Fig. 3;

Fig. 7 is a schematic wiring diagram of means for successively sensing (*a*) the instant marking the beginning of a predetermined time interval before a roll reaches a predetermined diameter, and (*b*) the instant the roll reaches that diameter;

Fig. 8 is a graphic representation of certain voltage variations occurring during the operation of the circuit illustrated by Fig. 7; and

Figs. 9 and 9A are schematic wiring diagrams of controls for accomplishing fully automatic operation of the splicing apparatus illustrated in Fig. 1.

While the invention has been shown and will be described in some detail with reference to a particular embodiment thereof, there is no intention to thus limit it to such detail. On the contrary, it is intended here to cover all alterations, modifications, and equivalents falling within the spirit and scope of the invention as defined by the appended claims.

The environment of the invention

Referring now to the drawings, and initially to Fig. 1, the invention has been illustrated by way of example as employed in web splicing apparatus for use with a newspaper printing press. In order that the invention may be fully understood, it will be helpful to set forth one environment in which it is employed. While the invention may be adapted by those skilled in the art to cooperate with various physical forms of splicing apparatus, that here shown by way of making the background clear is of the type disclosed in the copending U.S. application of Chase et al., Serial No. 502,923, filed April 21, 1955, and assigned to the assignee of the present application.

In general terms, a printing press **10** (here illustrated schematically in block form) is powered by variable speed drive means such as an electric motor **11** connected through a suitable speed controller **12** to a voltage source. By manually setting the controller **12**, the speed of the press may be adjusted to any value within a wide range. When the press is in operation, it consumes a web W of paper which is drawn upwardly from an expiring roll **14A**, the printing cylinders around which the web passes being omitted from the present illustration. It will be apparent, nevertheless, that the linear velocity of the running web W depends on the speed of the press 10 as determined by the setting of the speed adjusting means 12.

For a purpose to be made clear below, means are provided to sense the linear velocity of the running web W, or more specifically, to create a direct voltage which is proportional in magnitude to the linear velocity of the web. Since the rotational speed of the press drive motor 11 and the rotary components of the press 10 is in turn proportional to the web velocity, this sensing means in the present instance takes the form of a D.C. tachometer generator 16 which is connected to be driven by the press motor 11 or one of the press shafts which is powered by that motor.

In order to create running tension in the web W and assure its smooth passage upwardly into the press, an automatic running tensioning system is provided to retard the rotation of the supply roll 14A. This system is preferably of the pneumatic type disclosed and claimed in McWhorter U.S. Patent 2,743,881, to which reference may be made for a more detailed description. Briefly, the automatic tensioning system includes stationary friction straps 18 spaced apart over the axial length of the supply roll 14, fixed to tension springs 19 at their lower ends, and extending upwardly to anchor points 20, so that they partially wrap and frictionally engage the periphery of the expiring roll 14A. The running web W passes between spaced rollers 21, 22 and over a floating roller 24 carried by a depending arm 25 pivoted as at 26. As tension in the running web W increases or decreases, the arm 25 is rocked about its pivot 26, thereby shifting a connecting link 28 associated with a pneumatic controller 29 illustrated in block form. The controller 29 receives through conduits 30, 31 a supply of pressured fluid such as air stored in a reservoir 32 connected with a suitable compressed air source. In response to shifting of link 28 the controller 29 changes the pressure of air supplied through a conduit 34 to penumatic rams 35 having rollers 36 engaged with straps 18 near their lower ends.

If the web tension should increase or decrease, the resulting movement of the depending arm 25 causes the controller 29 to reduce or increase the pressure of air supplied to the rams 35, so that the roller 36 tightens or slackens the straps 18 to decrease or increase the retarding effect on the roll 14A. In this manner, and as more fully explained in the above-identified McWhorter patent, the tension in the running web W is automatically maintained at a predetermined value. In order that the automatically maintained tension may be adjusted, the conduit 30 includes a manually adjustable pressure regulating valve 38 which when adjusted changes the control point maintained by the controller 29. A pressure gauge 39 may be connected into the conduit 30 and calibrated to read directly in units of tension which will be automatically maintained.

When the web-supplying roll 14A is about to expire, the running web W is spliced to the leading end of the web on a new roll 14B without slowing down the travel of the web running into the press. To bring this about, the web splicing apparatus includes a reel assembly 40 made up of a main reel shaft 41 supporting at its opposite ends two spiders 42 having three arms 42*a*, 42*b*, and 42*c* spaced at 120° intervals. For the purpose of supporting web rolls for rotation about parallel axes, the arms of the spiders journal spindles 44*a*, 44*b*, and 44*c* on which the rolls are suitably chucked. To move each of the rolls to successive positions, and particularly to move the new roll 14B to a position in which its periphery is adjacent the running web W, a reel motor M is drivingly connected with the shaft 41 and energized through normally open contacts FOR1, FOR2, and FOR3 which are closed in response to energization of a contactor coil FOR.

Because the reel shaft 41 and spider 42 may rotate through 360°, the rolls chucked on the respective spindles 44*a*–44*c* move progressively to different positions. As illustrated in Fig. 1, the roll 14A may be termed the "expiring roll" since it is shown in the supply position with the running web W being drawn therefrom. The roll 14B may be termed the "new roll" since it is the one from which the running web will be drawn after the next splicing operation has been completed. The roll 14C may be termed "the newly-loaded roll" since it has just been chucked on the spindles 44*c* after the core of the previous expiring roll was removed therefrom.

In order to determine accurately and automatically when the new roll 14B has been translated to a position closely adjacent the running web W, a photoelectric device 47 may be mounted on the press frame and associated with a light beam source so that the light beam will be broken by the periphery of the new roll, and the photoelectric device actuated as the new roll reaches the desired position.

For a purpose to be described, means are provided to sense or indicate the instants at which the expiring roll 14A passes through two different angular positions. As here illustrated, first and second pairs of contact points CP1A and CP2A are carried by the spider arm 42*a*, and means such as a cam CA is associated with those points to open and close them as the spindle 44*a* passes through two respectively different angular positions (Fig. 1). As shown in more detail by Fig. 1A, cam CA is fixed to the spindle 44*a* and has a flat peripheral portion 43 which permits arms 53 biased by springs 53*a* associated with the movable contacts *m* to move radially inward and engage stationary contacts *s*. The cam CA thus causes the contact points CP1A and CP2A to open and close once during each revolution of the expiring roll 14A, and at respectively different instants when the roll is in different angular positions. Thus, it will be clear that the time interval between the opening of the points CP1A and the closing of the points CP2A is inversely proportional to the angular velocity ω of the roll 14A.

Because in the progress of reel rotation each of the spindles 44*a*–44*c* will carry an "expiring roll," the reel arms 42*b* and 42*c* are similarly equipped with contact points CP1B, CP2B and CP1C and CP2C, as well as cams CB and CC mounted on the spindles 44*b* and 44*c*. In order to connect the particular sets of contact points associated with the roll which at any given time is in the expiring position, the spider 42 carries a first slip ring 45 (Fig. 2) which is circular in extent, and a second slip ring 46 made up of three arcuate segments S_a, S_b and S_c. The spider arms also each carry two gravity-operated mercury switches, MS1A and MS2A, MS1B and MS2B, and MS1C and MS2C, respectively. The switches MS1A, B and C are constructed and oriented to close when their respective arms lie within the arc between the lines I and II, while the switches MS2A, B and C are constructed to close when their respective arms lie within the arc between the lines III and II (Fig. 1). Stationary brushes 48 and 49 ride on the slip rings 45 and 46 and cooperate with the mercury switches to complete selective electrical connections as will be apparent from the following description of Fig. 9. The brushes 48 and 49, the slip rings 45 and 46, and the mercury switches also serve to selectively connect in a circuit the contact points CP1B of the spider arm supporting the new roll 14B, these contacts being used to accurately time or phase the instants at which web deflecting and severing means are actuated, as will be more fully explained.

Also, in order to sense the angular positions of the reel shaft 41 and thus the positions of the rolls carried thereby as the reel rotates, a circular cam 50 is carried by the spider 42 (Fig. 2). The cam 50 cooperates with three stationary limit switches RLS1, RLS2, and RLS4 which are actuated whenever their followers drop into depressed portions 50*a* spaced at 120° intervals around the periphery of the cam. The three limit switches are so positioned that the switch RLS1 is actuated just at the instant that the new roll 14B makes initial contact with the stationary friction straps 18, as the reel shaft 41 rotates clockwise following a splicing operation. The limit switch RLS2 is so positioned that it is actuated when the new roll has become firmly engaged with the friction straps 18 as the shaft 44 rotates still further after a splicing operation has been completed. Finally, the limit switch RLS4 is so positioned that it will be actuated when the new roll has been moved, by clockwise rotation of the reel assembly 40, to a normal operating position where it becomes the expiring roll after a splicing operation has completed.

Besides the reel assembly 40 which rotatably supports the expiring roll 14A, the new roll 14B, and the newly loaded roll 14C, and permits their progressive movement in a circular path, the web splicing apparatus further includes means for predriving or rotating the new roll of 14B prior to the splicing operation in order that its peripheral speed will substantially match the linear velocity of the running web. Moreover, the predriving means are also employed in the present instance to retard the new roll immediately after a splicing operation to tension the web running into the press during that transition period required for the reel assembly to advance the new roll into engagement with the running tension straps 18. As here illustrated, the predriving and transition tension means include a predrive carriage 55 which is pivoted to swing about a shaft 56 between a raised or stowed position clear of the path of movement of the rolls supported by the reel assembly 40, and a lowered position in which it is in operative contact with the new roll 14B. The carriage 55 journals pulleys 58, 59 on either end over which is trained an endless belt 60. When the carriage 55 is lowered, the belt 60 engages the surface of the new roll 14B, and if the belt 60 is either driven or braked, it will serve to apply a driving or braking torque to the new roll 14B. For this latter purpose, the pulley 59 is drivingly connected with a predrive and braking motor PDM which is energized in a manner to properly control either its driving speed or its regenerative braking torque by an amplidyne 61 governed by a suitable control circuit 62. The control circuit 62 is responsive to a signal created by a tachometer generator 64 driven by a rotating part of the press 10, so that its output voltage is proportional in magnitude to the press speed, i.e., to the linear velocity of the running web W. Also, the control circuit 62 is responsive to a voltage created by a second tachometer generator 65 which is driven by a belt 66 trained over the pulley 59, so that the output signal of the tachometer 65 is proportional to the linear velocity of the belt 60 and therefore proportional to the peripheral speed of the new roll 14B. The manner in which the control circuit at 62 functions to govern the amplidyne 61 which in turn energizes the predrive motor PDM to create predriving or transition tensioning is more fully described in the above-mentioned copending application of Chase et al. Reference may be had to that copending application for further details.

In order to move or shift the predrive carriage 55 between its stowed and its operative positions, power means such as a double-acting pneumatic ram 69 is preferably employed. As here illustrated, the pneumatic ram at 69 has its piston rod 70 pivotally connected to the carriage of 55 so that upon extension and contraction of the ram the carriage will be swung counterclockwise and clockwise, respectively, about the shaft 56. To control the energization of the double-acting ram 69, a four-way solenoid valve 71 is interconnected between the opposite ends of the ram 69 and conduits leading to a fluid pressure source and the atmosphere. Since the movable part of the valve 71 need have but two positions, it is controlled by energizing or deenergizing an associated solenoid PRSOL. As illustrated in Fig. 1, the valve 71 is conditioned to extend the piston rod 70 and lower the predrive carriage 55 whenever the solenoid PRSOL is electrically energized. Conversely, when the solenoid is deenergized the ram 69 raises the carriage 55.

Once the new roll 14B has been moved to a position adjacent the running web W by rotation of the reel assembly 40, and the new roll 14B predriven so that its peripheral speed substantially matches the linear velocity of the running web W, the actual splicing of the running web to the leading end of the new roll web is accomplished by deflecting the running web against the surface of the new roll. It will be understood that a pattern of glue or other adhesive material is previously applied on the leading end of the new roll web, said adhesive pattern having axial discontinuities in the regions where the tensioning straps 18 and predrive belt 60 engage the new roll surface. This deflection of the running web W against the new roll 14B causes the leading end of the new roll web to adhere to the web W and start traveling into the press.

For deflecting and then severing the running web W, a paster assembly 75 is provided which includes a carriage 76 pivotally supported on a shaft 78 to swing between a retracted, stowed position clear of the path of movement of the reel-supported rolls, and a lowered or operative position adjacent the running web W but on the opposite side thereof from the new roll 14B. For causing remotely controlled, automatic raising and lowering of the paster carriage 76, power means such as a double-acting pneumatic ram 79 are associated with the carriage 76. As here shown, the ram 79 includes a piston rod 80 pivotally connected to the carriage 76, the ram being controlled by a four-way valve 81 (similar to the valve 71) which in turn is controlled by an electric solenoid PASOL. When the solenoid PASOL is electrically energized, the valve 81 is shifted to that one of its two positions which causes the ram 79 to lower the carriage 76 to its operative position adjacent the running web W.

Supported by the paster carriage 76 are means for deflecting the running web W against the periphery of the new roll 14B in order that the running web will adhere to the adhesive on the leading end of the new roll web. Such means are here shown as a plurality of brushes 84 spaced axially along the roll to clear the belts 18 and carried by arms fixed to a rotatable brush shaft 85. The shaft is cocked against the bias of torsion springs (not shown) to the position illustrated in Fig. 1 and held by means in the form of a latch cam 86 affixed to the shaft 85 and engaged by one arm of a bell crank 88. For releasing the latch and permitting the shaft 85 and brushes 84 to swing clockwise under the influence of the torsion springs, an electromagnetic brush solenoid BSOL is mounted on the carriage 76 so that when energized its armature extends to strike the crank 88 and shift it free of the latch cam 86. To signal that the brushes 84 have been released and the running web W deflected thereby against a new roll 14B, a brush limit switch BLS is mounted on the carriage 76 with its actuator engaging the latching crank 88. When the solenoid BSOL is energized to shift the latching crank 88 free of cam 86, the resulting movement of the latching crank trips the limit switch BLS.

Means are also provided to sever the old web drawn from the expiring roll 14A immediately after the brushes 84 have deflected the web against the glue pattern on the new roll 14B. As here illustrated, such means take the form of a plurality of serrated knives 90 spaced axially along the roll to clear the straps 18, being fixed to and rotatable with a shaft 91 journaled on the carriage 76. The shaft 91 is cocked against the bias of torsion springs (not shown) and held in the position shown by latch means such as a latching cam 92 fixed to the shaft 91 and engaged by one arm of a latching lever 94. To release the latching means and permit the knives **90** to swing clockwise for severing engagement with the old web, a knife solenoid KSOL is supported on the carriage **76** and positioned such that when the solenoid is energized its armature will engage and deflect the latching lever **94** free of the cam **92**. This release or actuation of the web-severing knives **90** is signaled by a knife limit switch KLS which is disposed to be actuated in response to unlatching movement of the lever **94**.

For sensing the position of the paster carriage **76**, a first carriage limit switch **1**CLS is mounted on a stationary support and located such that its actuator will be depressed by the carriage when the latter is fully elevated to the illustrated position. Two additional carriage limit switches **2**CLS*a* and **2**CLS*b*, here shown as mercury bottle switches, are mounted on the carriage so that the switch **2**CLS*a* is open when the carriage is elevated and closed when it is lowered, and so that the switch **2**CLS*b* is closed when the carriage is elevated and opened when it is lowered. These switches are used for control purposes as will be explained hereinafter.

Sensing and signaling roll diameters

In accordance with the present invention, the preliminary operations of rotating the reel assembly **40** to position the new roll **14**B, lowering the predrive and paster carriages **55** and **76**, and predriving the new roll **14**B are all initiated and carried out sequentially when the expiring roll **14**A reaches the first diameter, which at the then existing press speed leaves sufficient time for these preliminary operations to be completed before the actual splicing of the webs must take place. Further, the deflection of the running web W against a new roll **14**B and the severing of the expiring roll web are initiated and carried out sequentially when the expiring roll **14**A reaches a second, smaller, predetermined diameter indicative of the face that substantially all of the web on the expiring roll has been used up.

In order to determine when the expiring roll **14**B has reached such first and second diameters, means are provided to sense the angular velocity of the expiring roll, to sense the linear velocity of the running web, and to compare the two to establish when they have reached a certain ratio. The angular velocity of the expiring roll depends upon two things, viz., the linear velocity of the running web (press speed) and the diameter of the roll. The linear velocity of the web may be adjusted by the control means **12** (Fig. 1) to have any value within a wide range.

The preliminary operations of positioning the carriages and predriving the new roll always require about the same amount of time. But the faster the web speed, the greater is the rate of decrease in the diameter of the expiring roll. So, in accordance with one feature of the invention, the preliminary operations are initiated when the expiring roll has a diameter which is at least approximately proportional to the adjusted web velocity or press speed. This means that by the time the preliminary operations are completed the expiring roll has almost reached a certain diameter which is independent of the press speed.

To so initiate the preliminary operations when the expiring roll has a diameter related to the adjusted press speed, two signals varying as functions of the roll velocity and web velocity are generated, compared, and utilized to start the preliminary operations when one signal exceeds the other.

Then, after the preliminary operations are completed, the actual splicing is triggered when the expiring roll has been reduced to a certain, predetermined diameter which is always the same regardless of the adjusted value of the press speed. In keeping with one feature of the invention, this is accomplished by the same signal generating apparatus mentioned above, but with one of the signal generating means being modified to have a different input-output function. The two signals varying as functions (one modified) are compared, and utilized to trigger the actual splicing operation when one signal exceeds the other.

Referring now to Fig. 3, one arrangement is there illustrated for electrically determining when the expiring roll has reached a first diameter. The sensing of the angular velocity of the expiring roll involves the creation of a recurring signal having an asymmetrical wave form (see **104** or **112** in Fig. 4 or 8) and a frequency which depends upon such angular velocity. First, it will be recalled that the contact points CP**1**A and CP**2**A, appearing in Fig. 3, are sequentially actuated at instants when the expiring roll passes through respectively different angular positions, by virtue of the fact that the contacts are physically disposed on opposite sides of the actuating cam CA carried by the expiring roll spindle (Fig. 1). Thus, the time period which elapses between the opening of the first points CP**1**A and closing of second points CP**2**A during each revolution of the expiring roll **14**A is universely related to the angular velocity ω at which the expiring roll is turning.

To create a signal which repetitively varies substantially exponentially during the time period between the opening the first contact points CP**1**A and the closing of the second contact CP**2**A, a series circuit including a resistor component and a capacitor component is connected to a suitable direct voltage source. Such series circuit as here shown includes a capacitor C and a resistor R**1** connected in series with one another and across the conventionally represented direct voltage source E. The first set of contact points CP**1**A are connected directly in parallel with the capacitor C so that when those points are closed, the capacitor will be quickly and fully discharged, and the full magnitude of the voltage source E will appear across the resistor R**1**. However, each time instant the contact points CP**1**A open, the capacitor C will begin to charge exponentially, so that current flow through the resistor R**1** will decay exponentially producing a gradually and smoothly decreasing voltage drop e_R across that resistor. Thus, the longer the time elapsing after opening of the first contact point CP**1**A the smaller will be the voltage drop e_R appearing across the resistor R**1**. This shunting and discharging of the capacitor C followed by exponential charging of the capacitor C through the resistor R**1** will repeat for each revolution of the expiring roll as the contact points CP**1**A close and open.

To create a signal which is proportional in magnitude to the linear velocity of the running web W drawn from the expiring roll, the D.C. tachometer generator **16** (see also Fig. 1) is employed in the circuit of Fig. 3. Preferably, a resistance potentiometer **100** is connected directly across the terminals of the tachometer **16** so that the voltage e_v appearing between the slider **100***a* of the potentiometer and the negative terminal of the tachometer may be adjusted, thus changing the proportionality factor which relates the voltage e_v to the linear velocity v of the running web.

To determine when the expiring roll **14**A has reached a certain diameter indicating that the preliminary web splicing operations should be initiated, the repetitive exponential voltage variation appearing across the resistor R**1** is compared with the voltage e_v (which is proportional to the linear web velocity) at the instants that the second contact points CP**2**A close. For this purpose the second contact points CP**2**A, a current responsive signaling device here shown as the coil of a relay MP, a unidirectionally conductive device or diode **101**, and the voltage e_v are all connected in series across the resistor R**1**. The voltage e_v is poled to oppose or buck the varying D.C. voltage e_R which appears across the resistor R**1**, and the diode **101** is poled to permit current flow only if the voltage e_R exceeds the voltage e_v when the contact points CP**2**A are closed.

It will thus be seen that if the press is operating at a centain speed so that the web velocity-proportional signal e_v has a certain value, then as long as the expiring roll is rotating sufficiently slowly that the voltage across R1 decreases to a value less than the voltage e_v before the contact points CP2A close, then no current can flow to energize the current responsive device MP. On the other hand, if as the expiring roll decreases in diameter and its angular velocity correspondingly increases for a given linear velocity of the running web, then the time interval between the opening of the contact points CP1A and the closing of the contact points CP2A will decrease, so that the exponentially decreasing voltage e_R appearing across the resistor R1 will be larger than the voltage e_v at the instant that the contact points CP2A close. Under these circumstances, current will flow through the diode **101** and the relay coil MP. A momentary energization of the relay coil MP causes the re'ay to pick up, and this signaling may be utilized, as hereinafter described, to initiate the desired preliminary or final operations of the web splicing apparatus.

Figs. 4 and 5 are helpful in an understanding of how the circuitry illustrated in Fig. 3 operates to energize the current-responsive signaling device MP only when the expiring roll has been reduced to a desired diameter indicating that the preliminary operations of the web splicing equipment should be initiated. In Fig. 4, it is assumed that the printing press is operating at a certain speed S1 so that the running web W has a corresponding velocity. The voltage e_v produced by the tachometer **16** will therefore have a certain proportional and constant value represented by the line e_{v1} in Fig. 4. Now if when the expiring roll has a greater diameter than the predeterminad diameter d_1 at which it is desired to energize the relay coil MP, the expiring roll will have a relatively small angular velocity, and considerable time will elapse between the instants at which the contact points CP1A and CP2A respectively open and close. In Fig. 4 the time instants labeled "*a*" represent the instants that the contact points CP1A open, while the time instants marked "*b*" correspond to the instants at which the contact points CP2A close. It will be seen that during the intervals that the contact points CP1A are closed and the capacitor C is shunted, the voltage e_R appearing across the resistor R1 will be equal to the full magnitude of the voltage source E. Then, at each instant "*a*" when the contact points CP1A open, the voltage appearing across the resistor R1 will decay exponentially as shown by the curved portions **104**. As illustrated in the left portion of Fig. 4, if sufficient time elapses between the time instants "*a*" and "*b*," the exponentially decaying voltage e_R will fall below the voltage e_{v1} at the instants "*b*" when the contact points CP2A close. Under these circumstances, i.e., with the roll diameter greater than the predetermined diameter d_1, so that its angular velocity is relatively low, no current can flow through the relay coil MP since by the time the contact points CP2A close, the voltage e_R has decayed to a value less than the voltage e_{v1}.

On the other hand, and as graphically illustrated in the right portion of Fig. 4, when the expiring roll diameter is reduced to or is slightly less than the predetermined diameter d_1, then it must rotate at a higher angular velocity (for the same linear velocity of the running web), and the time intervals between the instants "*a*" and "*b*" when the contact points CP1A and CP2A respectively open and close, are considerably shortened. Therefore, by the time that the contact points CP2A close, the exponentially decaying voltage e_R appearing across the resistor R1 has not fallen below the magnitude of the velocity-proportional voltage e_v. Under these circumstances, therefore, when the contact points CP2A close at the time instants "*b*," the voltage e_R will exceed in magnitude the voltage e_v and current will flow through the diode **101** and the relay MP, thus actuating the latter.

In one sense the capacitor C, contacts CP1A, resistor R1 and contacts CP2A may be viewed as creating pulse-like signals whose amplitude is a function of the angular velocity of the expiring roll. That is, during those short time intervals that contacts CP2A are closed, a voltage is connected in series with the relay MP, and that voltage is in magnitude a non-linear function of the roll velocity.

It will be apparent that the angular velocity of the expiring roll, and thus the time intervals between the instants "*a*" and "*b*" depends upon the roll diameter, assuming that the press speed and linear velocity of the running web remain constant. However, if the press speed is increased or decreased so that the linear velocity of the running web W is correspondingly increased or decreased, that also will increase or decrease the angular velocity of the expiring roll and change the time interval between the time instants "*a*" and "*b*" even though the roll diameter remains substantially constant.

However, a change in the press speed or linear velocity of the running web does not adversely affect the operation of the sensing apparatus shown in Fig. 3. Referring to Fig. 5, the same graphic illustration of the voltage variations are illustrated as in Fig. 4 except that it is assumed that the press speed has been increased to a different value S2 so that the running web has a greater velocity and the magnitude of the proportional voltage e_v is increased to a value e_{v2}. Under these circumstances, when the expiring roll diameter is greater than the predetermined value d_1, the time intervals between the instants "*a*" and "*b*" will be short as contrastingly illustrated by the left portions of Figs. 4 and 5. But while these time intervals are shortened, the voltage e_{v2} has been proportionally increased so that the instants "*b*" when the contact points CP2A are closed, the exponentially decaying voltage e_R represented by the curve portions **104** has fallen below the increased value of velocity-proportional voltage e_{v2}. Thus, as illustrated in the left portion of Fig. 5, even through the press speed has been increased to a value S2, the diode **101** cannot conduct at the instants "*b*" when the contact points CP2A close, so that the relay MP remains deenergized.

As illustrated in the right portion of Fig. 5, by the time that the diameter of the expiring roll has become equal to or less than the predetermined diameter d_1, the angular velocity of the expiring roll has been further increased, so that relatively short time intervals occur between the time instants "*a*" and "*b*." Accordingly, at the instants "*b*" when the contact points CP2A close, the exponentially decaying voltage e_R will not have decreased below the value of the velocity-proportional voltage e_{v2}. Thus, when the contacts CP2A close, the diode **101** will permit current flow through the relay coil MP and energization of this relay may be caused, as hereinafter explained, to initiate the desired operations of the web splicing apparatus.

The foregoing explanation of the organization and operation of the circuitry illustrated by Fig. 3 may be made even clearer by a brief mathematical analysis. Since the period between the opening of the contact points CP1A and the closure of contact points CP2A is the time interval required for the expiring roll to rotate through a fixed, predetermined angle, that time period is inversely related to the angular velocity of the expiring roll. This may be expressed:

$$T=\frac{k_1}{\omega} \tag{1}$$

where

T=time period between instants a and b;
ω=angular velocity of expiring roll; and
k_1=proportionality constant.

But as previously explained, the capacitor C charges exponentially, beginning each instant that the contact points CP1A open. It is known that the exponentially decaying charging current as it varies with time may be written:

$$i=\frac{E}{R}\epsilon^{\frac{-t}{RC}} \quad (2)$$

where

i=charging current;
E=source voltage;
R=resistance of R1;
C=capacitance of C; and
t=time.

Since the value of the voltage e_R appearing across the resistor R1 is simply the product of the resistance value and the instantaneous current value, the variation of the voltage e_R with time measured from the instant that the contact points CP1A open may be written:

$$e_{R1}=iR1=E\epsilon^{\frac{-t}{RC}} \quad (3)$$

But it is also readily apparent that the linear velocity of the running web W and the angular velocity and instantaneous diameter of the expiring roll are related in the following manner:

$$v=\pi d\omega \quad (4)$$

where

v=linear velocity of web;
d=diameter of expiring roll; and
ω=angular velocity of expiring roll in revolutions per unit time.

Solving Equation 4 for ω and substituting Equation 1, the following expression may be obtained:

$$T=\frac{k_1\pi d}{v} \quad (5)$$

And substituting time T as expressed in Equation 5 for time t in Equation 3, the following may be written to express the value of e_{R1} at the instants b when the contact points CP2A close:

$$e_{R1}=E\epsilon^{-\left(\frac{k_1\pi}{R1C}\cdot\frac{d}{v}\right)} \quad (6)$$

Now it will be apparent from the previous explanation of the circuitry in Fig. 3 and the operation of the diode **101** that current can flow through the signaling device MP only when the voltage e_{R1} equals or slightly exceeds the voltage e_v at the instant T when the contact points CP2A close. Thus, the relay coil MP will be energized at one of the instants b only if at that instant

$$e_{R1}\geqq e_v \quad (7)$$

As previously explained, the velocity-proportional voltage e_v is simply directly proportional to the linear velocity of the running web, and thus may be expressed:

$$e_v=k_2v \quad (8)$$

where

e_v=velocity-proportional voltage
v=linear velocity of web; and
k_2=proportionality constant.

Substituting in Equation 7 the values of e_{R1} given by Equation 6 and e_v given by Equation 8, the following expression may be written which will determine the condition which must exist before the relay coil MP is energized:

$$E\epsilon^{-\left(\frac{k_1\pi}{R1C}\cdot\frac{d}{v}\right)}=k_2v \quad (9)$$

Taking the logarithm of both sides of Equation 9, this may be rewritten:

$$\frac{k_1\pi}{R1C}\cdot\frac{d}{v}=\log_\epsilon\left(\frac{k_2v}{E}\right) \quad (9a)$$

But it is well known from established mathematical principles dealing with logarithms that the positive logarithm of a number n is equal to the negative logarithm of the reciprocal of n, i.e., log

$$n=-\log\frac{1}{n}$$

Applying this to the value

$$\log_\epsilon\left(\frac{k_2v}{E}\right)$$

Equation 9a may be rewritten:

$$\frac{k_1\pi}{R1C}\cdot\frac{d}{v}=\log_\epsilon\left(\frac{E}{k_2v}\right) \quad (9b)$$

Solving for the diameter d:

$$d=\frac{R1C}{k_1\pi}\cdot v\cdot\log_\epsilon\frac{E}{k_2v} \quad (9c)$$

Breaking the last term of Equation 9c into a summation of logarithms which represents the indicated divisions, Equation 9c may be rewritten:

$$d=\frac{R1C}{k_1\pi}\cdot v\cdot(\log E-\log k_2-\log v) \quad (9d)$$

Since the expression

$$\frac{R1C}{k_1\pi}$$

is a constant, it may be represented as a composite constant K_1. Moreover, since E is a constant and k_2 is a constant, the quantities $\log E-\log k_2$ may be lumped and considered as a composite constant K_2. With this, Equation 9d may be rewritten:

$$d=K_1v(K_2-\log_\epsilon v) \quad (9e)$$

With reference to Equation 9e, the value of the term "log v" is made relatively small compared with the value of the constant K_2. This is accomplished in actual practice by making the D.C. voltage E relatively high and the proportionality factor k_2 relatively low. With this, the term log v is, for practical purposes, negligible in Equation 9e. Thus, that equation can be rewritten:

$$d\cong K_1K_2v \quad (10)$$

From Equation 10 it will be seen that the diameter d at which the relay coil MP is energized will be substantially proportional to the web velocity v, i.e., the press speed.

The result of this is that when the press speed is relatively high, the relay coil MP is energized when the roll diameter is relatively great, and when the press speed is relatively low, the relay coil MP is energized when the expiring roll diameter is relatively small. This gives a substantially uniform period of elapsed time during the instant that the relay coil MP is energized and the instant that the expiring roll reaches a second smaller predetermined diameter, or completely expires.

The foregoing explanation makes it clear how the signaling device MP is energized when the expiring roll **14A** reaches a certain diameter which is related to the press speed, and which signifies that the expiring roll has a certain time period to run before actual changeover to the new roll must take place. This time period will be almost constant for successive splicing operations, even though the press speed is different, and it insures that the positioning of the new roll **14B** by rotation of the reel assembly **40**, the lowering of the carriages **55** and **76**, and the predriving of the new roll **14B** by the predrive motor PDM and belt **60** are all accomplished in good time before the actual splicing and severing operations need occur.

In accordance with another aspect of the invention, means are provided to signify, as by energizing a current-responsive signaling device, when the expiring roll diameter has been further reduced to a certain fixed value which is independent of press speed and at which an actual changeover to the new roll web should take place.

To accomplish this, means are provided to create a signal which repetitively varies in substantially hyperbolic relation with time from the instants that the contact points CP1A open. As used herein, the term "hyperbolic variation" or "hyperbolic relation" refers to the general relation between variables x and y expressed by the equation $xy=k$, where k is a constant, or to a relation which is closely approximated by that equation. Since a high degree of precision is not vitally necessary, it has been found that it is possible to create a voltage variation which sufficiently approximates a hyperbolic relation with time by utilizing a modified resistance-capacitance charging or discharging circuit. This may be done quite simply by employing many of the components previously described in connection with Fig. 3. And as here shown in Fig. 3, it is done simply by closing a switch S*a* which connects the second resistor R2 directly in parallel with the capacitor C, thus changing the time constant of the circuit and increasing the steady state or limiting value of the voltage which appears across the series resistor R1.

Considering again Fig. 3, although as modified by the connection of the resistor R2 in parallel with the capacitor C, it will be seen that when the contact points CP1A are closed, both the resistor R2 and the capacitor C are shunted so that the capacitor is discharged and the full value of the voltage source E appears across the resistor R1. When the contact points CP1A open, the capacitor C begins charging exponentially by current flow through the resistor R1, but at the same time a portion of the current flowing through the resistor R1 passes through the resistor R2 which is in parallel with the capacitor. Accordingly, the voltage variation e_R appearing across the resistor R1 due to the current flow therethrough does not decay in a true exponential fashion but rather decays toward a steady state value equal to the source voltage E multiplied by the ratio of the values of R1 to R2. By proper choice of specific capacitance and resistance values, the variation in the voltage e_R appearing across the resistance R1 from the instant that the contacts CP1A open may be made to approximate a hyperbolic relation with passing time, at least over the time intervals during which sensing action takes place.

This is illustrated more clearly by the curves of Fig. 6 where the curve 105 represents a true exponential variation of the voltage e_R which would be obtained with the resistor R2 in Fig. 3 disconnected. The curve 106, by contrast, illustrates the voltage variation appearing across the resistor R1 when the switch S*a* in Fig. 3 is closed to connect the resistor R2 in parallel with the capacitor C. It will be seen from curve 106 in Fig. 6 that with the resistor R2 connected in parallel with the capacitor, the voltage e_R decays from an initial value E toward an asymptotic value

$$E\times\frac{R1}{R2}$$

and thus is flattened out considerably. Even though the voltage variation represented by the curve 106 has a finite value E at the instant when time t equals 0, the manner in which the voltage thereafter changes with time may be made to sufficiently approximate the hyperbolic variation with time, that is, a variation which substantially follows the mathematical relationship, $e_{R1}t=k$, where k is a constant.

In addition to creating a voltage signal which varies substantially hyperbolically with time from each instant that contact points CP1A open, the system illustrated in Fig. 3 further includes, as previously described, means such as the tachometer 16 and potentiometer 100 for creating a voltage e_v which is proportional to the linear velocity of the running web W. It also includes a series circuit made up of the contact points CP2A, the current-responsive signaling device or relay coil MP, the unidirectionally conductive device or diode 101, and the voltage e_v connected in series and across the resistor R1. It will be noted that the voltages e_R and e_v are connected with opposing polarity, in that diode 101 is connected to conduct only when the voltage e_R exceeds the voltage e_v at the time when the contacts CP2A are closed.

As previously indicated, the apparatus illustrated in Fig. 3 as modified by the closure of the switch S*a* to connect the resistor R2 in parallel with the capacitor C operates to energize the relay coil MP when the expiring roll diameter has been reduced to a predetermined value, and regardless of the particular speed at which the press may be operating. To make this more clear, a brief mathematical analysis of the operation will be helpful. Recalling, as previously explained in connection with Equation 1, supra, that the time period T between the opening of the contacts CP1A and the closing of the contacts CP2A is inversely related to the angular velocity of the expiring roll, the equation (1) may be reproduced here:

$$T=\frac{k_1}{\omega} \tag{11}$$

But the voltage variation shown by the curve portions 104 in Figs. 4 and 5 are not now exponential variations, but sufficiently approximate a hyperbolic variation for purposes of analysis. Thus, the instantaneous value of the voltage appearing across the resistor R1 at any time t after the opening of the contacts CP1A may be approximated by the expression:

$$e_{R1}t=k_3 \tag{12}$$

where

e_{R1}=voltage across resistor R1;
t=time measured from instant contacts CP1A open; and
k_3=a constant.

Substituting the value of time T from Equation 11 for time t in Equation 12, the following may be written to define the value of e_{R1} at the instants b when the contacts CP2A close:

$$e_{R1}=\frac{k_3}{k_1}\omega \tag{13}$$

The relationship between the linear velocity v of the running web, and the angular velocity ω and diameter of the expiring roll 14A are the same as expressed in Equation 4, supra, which may be reproduced here:

$$v=\pi d\omega \tag{14}$$

And, as expressed before in Equation 8, the value of the voltage e_v is proportional to the linear velocity of the running web:

$$e_v=k_2v \tag{15}$$

Solving Equation 14 for ω and substituting that expression in Equation 13, the following result is obtained:

$$e_{R1}=\frac{k_3}{k_1\pi}\cdot\frac{v}{d} \tag{16}$$

But, as expressed before in Equation 7, current flows to energize the relay MP only when the voltage e_{R1} appearing across the resistor R_1 is equal to or greater than the velocity-proportional voltage e_v at the time instant T that the contact points CP2A close. Thus, the relay MP will be energized if, at time T,

$$e_{R1}=e_v \tag{17}$$

Substituting the values of e_v and e_{R1} from Equations 13 and 16 in Equation 17, we obtain:

$$\frac{k_2}{k_1\pi}\cdot\frac{v}{d}=k_3v \tag{18}$$

$$d=\frac{k_2}{k_1k_3\pi} \tag{18a}$$

Since k_2, k_1, k_3 and π are all constants, Equation 18*a* may be written in simplified form:

$$d=K_1 \quad (19)$$

where K_1 is a composite constant.

It will be seen from Equation 19 that the value of the diameter d of the expiring roll when the relay coil MP is energized, is, in this instance, entirely independent of the particular velocity of the running web or the press speed which may then exist. In other words, regardless of the particular speed at which the press may be operating, the circuitry illustrated in Fig. 3 and as modified by the connection of the resistor R2 in parallel with the capacitor C to produce a substantially hyperbolic voltage variation across the resistor R1 will energize the relay coil MP whenever the expiring roll is reduced to a predetermined and preselectable diameter. This predetermination of the value of the expiring roll diameter when energization of the relay coil occurs may be made simply by adjusting the values of the constants k_1, k_2, k_3 in Equation 18*a*, and it may be most easily accomplished by either changing the setting of the potentiometer wiper **100***a* to change the constant k_2, or by changing the values of the resistors R1 or R2, as well as by changing the value of the capacitor C. This energization of the relay coil MP at an instant when the expiring roll has reached the predetermined fixed diameter, is utilized, as explained below, to initiate the action of the web deflecting and severing means.

Returning now to Fig. 7, there is illustrated a preferred arrangement for successively energizing a current-responsive signaling device exemplified by the relay coil MP, first when the expiring roll reaches a diameter related to the speed at which the press is operating, and secondly, for energizing that same relay coil MP when the expiring roll has been reduced further to a second and smaller predetermined diameter which is substantially always the same regardless of the speed at which the press is operated.

It will be seen that the circuit of Fig. 7 in its normal state with none of the relays energized, presents a series circuit comprising normally closed relay contacts X5, and the capacitor C connected in series with two resistors R1, R1*a* across a direct voltage source E. Thus, a fairly high value of charging resistance made up of the two resistors R1 and R1*a* in series is operatively connected in the circuit. The contact points CP1A, as previously explained in connection with Fig. 3, are connected in parallel with the capacitor C. Two potentiometers **110** and **111** having adjustable sliders **110***a*, **111***a* are connected across the tachometer **16**, the sliders being connected alternatively through normally closed contacts X2 and normally open contacts X3 of a relay X to the diode **101**.

Under these circumstances, a series combination of the contact points CP2A, the relay coil MP, the diode **101**, and a first voltage e_{va} (which is proportional to the linear velocity of the running web) is connected directly across the two series-connected resistors R1 and R1*a*. Therefore, as the contact points CP1A and CP2A successively open and close, the voltage appearing across the two resistors R1 and R1*a* will decay exponentially as shown by the curves **112** in the left portion of Fig. 8. When the expiring roll is reduced to the first diameter d_1 so that its angular velocity increases sufficiently to shorten the time interval between the instants "*a*" and "*b*" at which the contacts CP1A and CP2A respectively open and close, the voltage appearing across the resistors R1 and R1*a* will exceed the voltage e_{va} appearing across the potentiometer **110** when the contact points CP2A close, so that the diode **101** will permit current flow through the relay MP. This, as previously explained, will occur when the expiring roll reaches a diameter which is related to or substantially proportional to the press speed, since the capacitor C connected in series with the resistors R1 and R1*a* will charge exponentially. As a result, the relay coil MP will be energized for the first time at an instant which signifies that the expiring roll contains a sufficient quantity of the paper web to permit operation for a given interval of time, say about one and one-half minutes.

When the coil MP is energized, the contacts controlled by that relay may be used, as hereinafter explained, to initiate the preliminary operations of the web splicing apparatus. But further energization of the relay coil MP results in momentary closure of the normally opened contacts MP*a* (Fig. 7) which are connected in series with the coil X of an auxiliary relay across the voltage source E. Accordingly, the relay X will be energized and sealed in by its own normally open contacts **X1**. At the same time the relay contacts X2 will open, and the relay contacts X3 will close to disconnect the slider **110***a* from the circuit including the diode **101** and reconnect in its place the slider **111***a*. Accordingly, a different proportionality factor is established for the web velocity-proportional voltage and in this instance, a velocity-proportional voltage e_{vb} will be established. As illustrated in the right portion of Fig. 8, the voltage e_{vb} is considerably greater in magnitude than the voltage e_{va} even though the press speed has remained constant at the value **S1**. Further, when the relay X is energized, its contacts X4 close to shunt the resistance R1*a*, its contacts X5 open to isolate the capacitor C, and its contacts X6 close to connect the parallel combination of a resistor R2 and a capacitor C1 of a different value in the place of the original capacitor C.

It will be apparent, therefore, that under these circumstances a smaller resistance value made up only of the resistance R1 is connected in series with the capacitor C1 across the voltage source E, and that a resistance R2 is connected in parallel with the capacitor. This results in substantially the same circuit as represented by Fig. 3 with the switch S*a* closed, except that the relay X, picked up in response to momentary energization of the relay MP, serves to change the proportionality constant relating the voltage e_v to the linear velocity of the running web, and serves to change the value of the charging resistance, as well as to change the value of the capacitance, and to place the resistor R2 in parallel with the effective capacitor.

The effect of the relay X and its contacts, therefore, is to modify the circuit illustrated in Fig. 7 from one in which the voltage variation across the resistor R1 decays substantially exponentially with time from the instants that the contacts CP1A open to a circuit in which the voltage variation appearing across the resistance R1 decays substantially hyperbolically with time. This, as made clear from the foregoing description with reference to Fig. 3, will result in the relay coil MP being energized a second time when the expiring roll reaches a smaller predetermined diameter d_2. As illustrated in the right portion of Fig. 8, the voltage appearing across the resistor R1 decays substantially hyperbolically with time as represented by the curve portions **114**, from the instants "*a*" that the contact points CP1A open. When the expiring roll has been reduced to a predetermined diameter d_2, the instants "*b*" which represent the closure of the contacts CP2A will occur sufficiently promptly after every instant "*a*" such that the voltage e_{R1} appearing across the resistor R1 will at that instant exceed the web velocity-proportional voltage e_{vb}, so that the diode **101** will conduct and relay coil MP will be energized a second time.

Fully automatic controls and operation

With the foregoing in mind, reference may now be had to the wiring diagram of a control system illustrated in Figs. 9 and 9A for a complete understanding as to how all of the operations necessary to splice a running web to a new web roll are carried out automatically and without any attention or action on the part of an attendant. Throughout Figs. 9 and 9A, the electrical contacts controlled by each relay or limit switch have been given the same reference character as the relay coil or the limit switch itself which controls those contacts, a distinguishing suffix being added for each set of contacts where more than one set is controlled by a single relay coil or limit switch.

The photoelectric means **47** for sensing when the new roll has reached a predriving position adjacent the running web shown in Fig. 1 appear in Fig. 9 as a light source **120** connected for energization across A.C. voltage supply lines **L1**, **L2**, and positioned at one end of the reel assembly **40**. Cooperating with that light source is a photocell **121** having its cathode and anode connected to receive the D.C. potential appearing across a filtering capacitor **122** charged by a rectifier **124** connected across the lines **L1**, **L2**. The coil of a photoelectric relay PE is connected in circuit with the anode and cathode of the photocell **121**, so that when the light beam from the lamp **120** is broken by the periphery of the new roll, conduction of the photocell **121** is terminated and the relay PE deenergized. Thus, it will be understood that the relay PE is normally energized except when the new roll **14B** is moved to a position adjacent the new web and thus interrupts the light beam.

The current-responsive signaling device which is energized whenever the expiring roll reaches predetermined diameters as previously described in connection with Figs. 3 and 7, is illustrated in Fig. 9A as a relay having a coil MP. Because it is desirable that the relay MP be actuated when only a very small current flows through, and even though that current flow exists for a very short time interval, the relay MP is preferably a low inertia, fast acting type of relay and one which mechanically "latches in" its actuated position when it is once actuated. Thus, it should be understood that in the preferred form illustrated in Fig. 9A, the relay MP is a sensitive, latching type of relay and that upon momentary flow of a small current therethrough it will be picked up. Then, even though that current is terminated, the relay MP remains picked up until a voltage of opposite polarity is applied to its coil which causes it to drop out or return to its original de-actuated condition.

It will also be understood from Fig. 1 that since the reel assembly **40** turns through 120° each time that a complete web splicing operation takes place, each of the spider arms **42*a*–42*c*** will in succession, carry what has been designated as the expiring roll **14A**, the new roll **14B**, and the newly loaded roll **14C**. That is, while the apparatus as illustrated in Fig. 1 shows the expiring roll **14A** supported on the spider arm **42*a***, after a splicing operation has caused the running web W to be drawn from the new roll **14B**, the latter roll will be positioned through rotation of the spider **42** substantially in the location presently shown for the expiring roll **14A**.

In order that the control circuitry will operate properly, regardless of which of the three spider arms is at that instant carrying the expiring roll, the newly loaded roll, and the new roll, the contact points CP1A, CP2A, CP1B, CP2B, CP1C and CP2C are connected in circuit with the several mercury switches MS1A—MS2C and the slip rings **45** as shown in Fig. 9*a*. With the reel assembly **40** in the position illustrated by Fig. 1, the mercury switches MS1A and MS2A will be closed to connect the contact points CP1A and CP2A in a diameter-sensing circuit for the expiring roll **14A**. As shown, such circuit includes the slip ring segments SA and SC cooperating with two of the stationary brushes **49**. However, if the reel assembly **40** is rotated through 120° so that the arm **42*b*** then supports the "expiring roll," the positions of the slip ring segments SA, SB and SC as well as the condition of the several mercury switches will be changed, so that the contact points CP1B and CP2B will then be placed in the diameter-sensing circuit in lieu of the contact points CP1A and CP2A.

In a similar manner, it may be observed that with the reel assembly **40** in the position illustrated by Fig. 1, the contact points CP1B which open and close one time for each revolution of the new roll **14B** as it is being predriven, are connected in circuit through the closed mercury switch MS1B and the slip ring segment SB to a brush **49** connected through relay contacts PA4 and PDS1 to the coil of a relay F. The purpose of this will be made clear in the following detailed description, and it is sufficient here to note only that upon rotation of reel assembly **40** through 120° the contact points **CP1B** will be replaced in this circuit by the contacts **CP1C** carried by the arm **42C** which will then be supporting the "new roll."

In summary, the slip rings **45** and **46** together with the mercury switches as illustrated in Figs. 1, 2 and 9A, serve to permit successive identical operation to be performed on the expiring new and newly loaded rolls by establishing different circuit connections to the several contact points indicative of which particular contact points are at any time, according to the angular position of the reel assembly, associated with the expiring roll, the new roll, or the newly loaded roll.

The organization and operation of the automatic control circuitry illustrated in Figs. 9 and 9A may be made clear by describing one complete functional cycle. It will be helpful, however, to briefly set forth the initial conditions which prevail before the beginning of that operational cycle. Assume, first, that the press is running normally at a speed which has been determined by setting of the speed adjusting means **12** in Fig. 1. The expiring roll **14A** will be in its regular supply position, i.e., with the spider arm **42A** extending substantially horizontally. The new roll **14B** will, therefore, not yet be positioned adjacent the running web. And the predrive carriage **55** and the paster carriage **76** will both be in their raised or retracted positions.

Correspondingly, the following initial conditions will prevail in the control circuitry illustrated by Figs. 9 and 9A. The coil of a relay MPR (at the bottom of Fig. 9) will be energized and that relay picked up since it is connected directly across the voltage lines **L1**, **L2**, by the normally closed relay contacts **POS1**. Thus, the relay contacts MPR1 and MPR2 (adjacent the relay coil MP, Fig. 9A) will be closed, and the normally closed contacts MPR3 and MPR4 will be open. Since the mercury switches **MS1A** and MS2A are closed owing to the angular position of the spider **42**, the relay coil MP will be connected through the diode **101**, normally closed relay contacts CRY1, and the slider **110A** of a first adjustable potentiometer **110**, to one side of the series-connected resistors R1, R1*a*. Similarly, the relay coil MP will be connected through the contacts **MPR1**, the slip ring segment SC, the closed mercury switch contacts MS2A through the contact points CP2A and the mercury switch 1A, thence through the slip ring segment SA and the associated brush **49** to the opposite end of the series connected resistors R1, R1*a*. There is thus provided the series circuit which includes the signaling relay coil MP and which is very similar to that previously described in connection with Fig. 7.

Also, it will be observed that a capacitor C is connected through normally closed relay contacts CRY3 and in series with the resistors R1, R1*a*, directly across the D.-C. voltage source represented by the battery E. Thus, there is established an R-C charging circuit similar to that described in connection with Fig. 7. Further, the contacts CP1A are connected in parallel with the capacitor C through the slip ring **45** and the associated brush **48**, as well as through the closed mercury switch contacts **MS1A**, the slip ring segment SA and the associated brush **49**. Under these circumstances, therefore, substantially identical circuit connections, such as those shown in Fig. 7 before the initial energization of the relay MP are established by the mercury switches and the slip rings.

In operation, therefore, as the expiring roll **14A** (Fig. 1) makes each revolution and the contact points **CP1A** and CP2A open and close, the capacitor C will be discharged each time that the contacts CP1A are closed by current flow over the path shown by the dot-dash line in Fig. 9A. Each time that the contact points CP1A open, the capacitor C will charge from the battery E through the series-connected resistors R1 and R1*a* by current flow over the path indicated by the double-dot-dash line in Fig. 9A. Since it is assumed that the diameter of the expiring roll is at this time fairly large, i.e., the roll is not appreciably used up, each time that the contact points CP2A close after a relatively great time period has elapsed since the contact points CP1A opened, the exponentially decaying voltage appearing across the resistors R1, R1*a*, will have decreased to a value below the magnitude of the voltage e_{va} appearing at the slider **110***a* of the resistance potentiometer **110**, so that the diode **101** will not permit current to flow through the relay coil MP.

The capacitor C thus continues to be charged and discharged each time that the expiring roll makes one revolution. When the expiring roll **14**A reaches a certain diameter related to the speed at which the press is operating, the value of the exponentially decaying voltage appearing across the resistors R1, R1*a*, will exceed the magnitude of the voltage e_{va} appearing across the potentiometer **110** and which is proportional to the press speed, when the contact points CP2A close. Therefore, the diode **101** will permit the current flow momentarily through the relay coil MP, such current following a path as indicated by the arrows on the dotted line in Fig. 9A. This will occur, as previously explained, when the diameter of the roll has reached a certain value determined by the adjustment of the constants in Equation 9*b*, supra; and as previously explained with reference to Equation 10, if the press speed is relatively high or low, this critical diameter at which energization of the relay MP occurs, will be relatively greater or lesser.

When the relay MP is momentarily energized, this signifies that the time has arrived for the preliminary operations of the web splicing apparatus to begin. Such momentary energization of the relay MP latches it in an actuated position. Thus, the relay contacts MP1 in the upper portion of Fig. 9 close and remain closed to energize through the normally closed relay contacts POS4, the coil of a time delay relay TR.

Closure of the contacts MP1 also energizes an audible signal device connected in parallel with the time delay relay coil TR. This audible signal may serve to warn personnel at various locations, such as at the folder, of the printing press that a splicing operation is about to take place.

After a predetermined delay, on the order of two seconds, from the instant that the relay coil TR is energized, its contacts TR1 will close, thus energizing the coil of a relay CRX. Pick-up of this latter relay closes its normally open contacts CRX1 so that the contactor coil FOR is energized through the normally closed contacts 1CLS–*b* and the photoelectric relay contacts PE1 (which will be closed since the light beam from the lamp **120** will be uninterrupted). It will be observed that closure of the CRX1 contacts cannot energize the relay coil POS since the photoelectric relay contacts PE–2 will at this time be open. Moreover, closure of the normally opened contact CRX2 (in the middle portion of Fig. 9) cannot result in energization of a relay coil PA, since the auxiliary line L4 will be isolated from the line L1 by the open contacts POS2, 2CLS*a* and PD1.

In response to the energization of the contactor coil FOR, the contacts FOR1–FOR3 in Fig. 1 will close, thereby energizing the reel motor M and turning the reel assembly **40** in a clockwise direction. When the new roll 14B reaches its predrive position adjacent the running web W, its periphery interrupts the light beam from the lamp **120** (Fig. 9) thereby deenergizing the photoelectric relay PE. As a result, the contacts PE1 open to deenergize the contactor coil FOR and terminate reel rotation, while the contacts PE2 close to energize the relay coil POS.

Several things happen in response to this energization of the relay coil POS. First, the normally open contacts POS2 close to seal in the POS relay through the normally closed limit switch RLS4. This places an auxiliary line L3 at the same potential as the line L1.

Secondly, the normally open POS3 contacts (in the upper portion of Fig. 9) close to prepare an energization path for the relay coil CRX.

Thirdly, the normally closed POS4 contacts open to drop out the time delay relay TR and to deenergize the audible signal, the contacts TR1 thus opening although the relay CRX remains energized through the now closed contacts MP1 and POS3.

Fourthly, the normally closed POS1 contacts (at the bottom of Fig. 9) open to deenergize the relay MPR. In response, the MPR1 and MPR2 contacts in Fig. 9A open, while the MPR3 and MPR4 contacts close, the latter contacts placing a reversed polarity voltage on the relay MP in order to cause the latter to unlatch and drop out. With the relay MP deactuated, the contacts MP1 (in the upper portion of Fig. 9) open, thus deenergizing the relay coil CRX. For so long as the relay MPR is deenergized and the contacts MPR1–4 in Fig. 9*a* thus placed in their normal states, no energization of the relay MP can occur in response to closure of the CP1A and CP2A contact points.

Fifthly, the POS6 contacts in Fig. 9A close to short out the resistance R1A, thereby reducing the effective value of resistance contained in the R-C charging and discharging circuit in a similar manner to that explained above in connection with the X4 contacts in Fig. 7. This in effect changes or reduces the time constant of the charging or of the R-C charging and discharging circuit.

Sixthly, the POS5 contacts in Fig. 9 close to create an energization path through the normally closed contacts PDSX1 and FOR4 for the paster carriage solenoid PASOL. In response to this latter energization, the valve **81** (Fig. 1) is shifted to cause the pneumatic ram **79** to lower the paster carriage **76** toward its operative position adjacent one side of the running web W. As the paster carriage begins to lower, the limit switch 1CLS is released so that its normally closed contacts 1CLS*b* in Fig. 9 are opened and the normally open contacts 1CLS*a* are closed. Thus, as soon as the paster carriage **76** begins to lower, the contacts 1CLS*a* in Fig. 9 close to energize a relay coil CRY, and also to energize the predrive carriage solenoid PRSOL through the now closed relay contacts POS7 and the normally closed contacts PA1.

In response to the energization of the relay CRY, its normally closed contacts CRY1 (Fig. 9A) open to disconnect the diode **101** from the potentiometer **110**; while the contacts CRY2 close to reconnect the diode **101** to the slider **111***a* of the potentiometer **111**. In this manner, the proportionality constant which relates a voltage taken from the tachometer **16** to the speed of the running web W is automatically changed after the first predetermined diameter has been sensed by the initial energization of the relay MP.

It will also be seen that pick-up of the relay CRY results in opening of the contacts CRY3 and closure of the contacts CRY4 (Fig. 9A), so that the capacitor C is replaced in the R-C charging and discharging circuit by the parallel combination of a second capacitor C1 and a parallel-connected resistor R2. The purpose and effect of this are the same as previously described in connection with Figs. 3 and 7, creating a charging and discharging circuit which will produce a repetitively varying voltage across the resistor R1 which decays substantially hyperbolically with time from the instants that the contact points CP1A open.

As noted above, closure of the contacts 1CLS*a* energized the solenoid PRSOL. When this occurs, the valve **71** (Fig. 1) is shifted to cause the pneumatic ram **69** to lower the predrive carriage **55** until the belt **60** rests against the peripheral surface of the new roll **14B**. At about this time, therefore, both the paster carriage **76** and the predrive carriage **55** are lowered. As the paster carriage **76** reaches its fully lowered position, the carriage limit switches **2**CLS*a* and **2**CLS*b* are actuated. As seen in Fig. 9, closure of the switch **2**CLS*a* results in energization of a relay coil PD through the normally closed limit switch contacts RLS**2**, and also results in energization of the relay coil PDX through the normally closed reel limit switch contacts RLS**1**. As a result, the normally open contacts PD**2** close to seal in the predrive carriage solenoid PRSOL, and the normally open contacts PD**1** close to seal in both the relays PD and PDX.

The energization of the relays PD and PDX causes the control circuit **52** (illustrated in block form in Fig. 1) to so energize the amplidyne **61** that the predrive motor PDM is effective to rotate the pulley **59** and drive the belt **60**. As a result of its frictional contact with the surface of the new roll **14B**, the belt **60** positively drives the new roll in a counterclockwise direction, and the control circuit **62** together with the amplidyne **61** are effective to bring the speed of the new roll to a point at which its peripheral velocity substantially matches that of the running web. This is termed the "predriving" operation and assures that there will be no abrupt pull on the running web which might rupture it when it is deflected against and adheres to the glue pattern on the leading end of the new roll web. Since the details of the organization and operation of the control circuit **62** and the predriving amplidyne **61** controlling the predriving motor PDM form no part of the present invention, they will not be here described. However, a better understanding may be had by a reference to the copending application of Chase et al., Serial No. 502,923, filed April 21, 1955, and assigned to the assignee of the present invention.

Returning now to the circuitry of Fig. 9, it will be seen that as predriving begins in response to closure of the contacts **2**CLS*a* and energization of the relay PD after the paster carriage is fully lowered, the relay coil PDS will also be energized in response to closure of the contacts of the carriage limit switch contacts **2**CLS*a* by current flow through the normally closed contacts PDSX**2**. Pick-up of the relay PDS first causes closure of the contacts PDS**1** (Fig. 9A) to partially complete an energization path for a relay coil F. Also, energization of the relay PDS results in closure of the contacts PDS**2** (at the bottom of Fig. 9) so that the relay MPR is again energized.

Energization of the relay MPR results in opening of the contacts MPR**3**, **4** and closing of the contacts MPR**1**, **2**. As a result, the sensitive current relay MP is placed in series with the contact points CP**2**A, the diode **101** and the potentiometer **111** across the charging resistor R**1**. The sensing circuit is thus now ready to detect when the expiring roll reaches a second predetermined smaller diameter. The R-C charging circuit now consists of the resistor R**1** alone in series with the capacitor C**1** across the voltage source E, the resistor R**2** being connected in parallel with the capacitor C**1**. As a result, the voltage variation across the resistor R**1** decays substantially hyperbolically with time from each instant that the contacts CP**1**A open.

As the contacts CP**1**A open and the contacts CP**2**A close, each time that the expiring roll makes one revolution, the sensitive relay MP will not be energized if a sufficient time elapses such that the voltage appearing across the resistor R**1** is less in magnitude than the voltage e_{vb} appearing on the potentiometer slider **111***a* at the instant that the second contact points CP**2**A close. However, when the expiring roll reaches a predetermined small diameter indicating that there is substantially no remaining web thereon, then the expiring roll will have such a high angular velocity in relation to the press speed that the contact points CP**2**A will close very shortly after the contact points CP**1**A open, and a time when the hyperbolically decaying voltage across the resistance R**1** exceeds the voltage e_{vb} appearing at the potentiometer slider **111***a*. When this happens, indicating that the second predetermined diameter has been reached, current will flow through the diode **101** and thus energize the sensitive relay MP which will pick-up and latch in.

In response to this pick-up of the relay MP, the contacts MP**1** (in the upper portion of Fig. 9) will again close. This will not result in energization of the time delay relay TR since the POS**4** contacts are now open. However, closure of the contacts MP**1** will result in energization of the relay coil CRX through the now closed contacts POS**3**. When the relay CRX is energized the second time, closure of its contacts CRX**1** will have no effect, because the carriage limit switch **1**CLS*b* is now open. However, closure of the contacts CRX**2** will result in energization of a relay coil PA which seals in to the auxiliary line L**3** through its own normally open contacts PA**2**. Pick-up of the relay PA also closes the normally open contacts PA**4** in series with the relay coil F, so that the latter is now connected across the voltage source E through the slip ring **45**, the contacts CP**1**B associated with the new roll **14B**, the closed mercury switch MS**1**B, the slip ring segment S_b, the contacts PA**4** and the contacts PDS**1**.

Thus, the next time that the contacts CP**1**B close, to indicate that the glue pattern on the new roll **14B** is in a certain angular position relative to the running web W, the relay F will be energized. As a result, the contacts F**1** (Fig. 9) close to energize the relay coil D which seals in to the auxiliary line L**3** through the now closed contacts PA**2** and its own normally open contacts D**1**. Energization of the relay F does not energize the brush solenoid BSOL since the normally closed contacts F**2** open at the same instant that the contacts F**1** close.

Then, when the contact points CP**1**B again open as the predriven new roll **14B** rotates further, the relay F will be deenergized, thereby causing the contacts F**2** in Fig. 9 to reclose and create an energization path through the now closed contacts D**1** for the brush solenoid BSOL. Energization of this solenoid, as previously noted in connection with Fig. 1, will result in release of the latch for the spring-biased brush shaft **85**, so that the brushes **84** will deflect the web W against the periphery of the new roll **14B**. As the glue pattern on the leading end of the new roll web passes into contact with the deflected running web W, the two will adhere so that the web from the new roll thus passes upwardly into the printing press. It will also be observed from Fig. 1 that when the brush shaft latch is released, the limit switch BLS is actuated.

Actuation of the limit switch BLS results in closure of the contacts BLS**1** and BLS**2** shown in Fig. 9. This will not result in energization of the solenoid KSOL or the relay PDSX, since at this instant the relay F is deenergized and its contacts F**4** are open. However, as soon as the spindle supporting the new roll **14B** completes one revolution and the contacts CP**1**B again close, the relay F will be energized a second time. Accordingly, the contacts F**4** will close and result in simultaneous energization of the solenoid KSOL and the relay coil PDSX through the now closed contacts BLS**2** and BLS**1**.

Energization of the knife solenoid KSOL releases the latch lever **94** shown on the paster carriage in Fig. 1, so that the shaft **91** turns under the influence of biasing springs and deflects the knives **90** into severing engagement with the web being drawn from the expiring roll. The expiring roll web is thus severed so that thereafter the running web W is taken from the new roll **14B**.

Upon energization of the relay coil PDSX, it is sealed in through its own normally opened contacts PDSX**4** and the now closed contacts PA2. Also, energization of the relay coil PDSX affects the control circuit **62** diagrammatically shown in Fig. 1 so that the amplidyne **61** now serves to constitute motor PDM as a regenerative braking device, as explained in the above-identified Chase et al. application. Thus, the motor PDM exerts a retarding force on the predrive belt **60** so that the latter resists rotation of the new roll **14B** and creates transition tension in the running web.

Upon energization of the relay PDSX, its contacts PDSX3 in Fig. 9A close to seal in the relay F so that the latter is not picked up and dropped out in response to further opening and closing of the contacts CP1B as the new roll **14B** rotates. Also, the normally closed contacts PDSX2 open at this time to deenergize the relay PDS which has a further effect in the control circuit **62** (Fig. 1) to cause transition tensioning of the web drawn from the new roll.

Drop out of the relay PDS also causes its contacts PDS2 (at the bottom of Fig. 9) to open, so that the relay MPR is again deenergized. Accordingly, the contacts MPR1, 2 (Fig. 9A) reopen to isolate the sensitive relay MP from the series circuit connected across the resistor R1; while the contacts MPR3, 4, close to apply a reversed polarity voltage to the sensitive-latching relay MP, thus causing the latter to be released and deactuated. Drop out of the sensitive relay MP results in opening of the contacts MP1 in the upper portion of Fig. 9 and this results in deenergization of the relay CRX so that its contacts CRX1 and CRX2 are open for the rest of the operational cycle.

Still further, the previous energization of the relay PDSX causes the normally closed contacts PDSX1 so that the solenoid PASOL in series therewith is deenergized. The paster carriage solenoid valve **81** (Fig. 1) is returned to its normal position, causing the pneumatic ram **79** to retract the paster carriage **76** upwardly toward its stowed position.

As the paster carriage **76** starts to retract, the carriage limit switch contacts 2CLS*a* (Fig. 9) reopen, but the now closed contacts PD1 maintain the predrive solenoid PRSOL energized. Moreover, as the paster carriage **76** starts to retract, the limit switch contacts 2CLS*b* in the upper portion of Fig. 9 reclose to energize the contactor coil FOR through the now closed contacts PA3. Thus, the contacts FOR1–3 (Fig. 1) are closed to energize the reel motor M so that the spider **42** rotates clockwise to advance the new roll **14B** toward the tensioning straps **18**. This advances the new roll **14B** toward the regular supply position in which it will then become the expiring roll, and moves the spider arm **42*a*** toward the position illustrated for the arm **42*c***, where the core of the expired roll may be removed and replaced by a newly loaded roll.

As the reel assembly rotates clockwise, just as the new roll makes initial contact with the tensioning straps **18**, the cam **50** will cause actuation of the reel limit switch RLS1 (Fig. 2) so that its normally closed contacts (Fig. 9) will open to drop out the relay PDX. This, as explained in more detail in the above-mentioned Chase et al. application causes the control circuit **62** shown in Fig. 1 to so control the amplidyne **61** that the transitional braking effort created by the motor PDM and transferred to the new roll through the belt **60** is gradually reduced as the new roll moves into the regular tensioning straps **18**.

As the reel assembly **40** continues to rotate in a clockwise direction and when the new roll **14B** has moved to a firm engagement with the tensioning straps **18**, the cam **50** actuates the reel limit switch RLS2 (Fig. 2). As seen in Fig. 9, actuation of the switch RLS2 to open its normally closed contacts results in deenergization of the relay PD. Thus, the relay contacts PD2 open to deenergize the solenoid PRSOL. As a result, the valve **71** is restored to its original condition and the pneumatic ram **69** swings the predrive carriage **55** upwardly to its stowed position.

Then, as the paster carriage **76** reaches its fully retracted position, and engages the actuator of the first carriage limit switch 1CLS (Fig. 1), the contacts 1CLS*a* are restored to their original condition, i.e., opened, so that the relay CRY is deenergized. This restores the four relay contacts CRY1–CRY4 to their original condition, so that the capacitor C is replaced in the R-C charging and discharging circuit, and the diode **101** reconnected to the slider **110*a*** of the potentiometer **110**.

As the reel spider **42** rotates further in a clockwise direction to locate the new roll **14B** in a normal operating position, the cam **50** causes the reel limit switch RLS4 (Fig. 2) to be actuated, so that its normally closed contacts (Fig. 9) open, thereby deenergizing the relay POS. When this occurs, the contacts POS2 open, thus disconnecting the auxiliary lines L3 from the main voltage supply line L1, so that all of the relays shown beneath the POS relay in Fig. 9 (with the exception of the relay MPR) are deenergized and restored to their original condition. Also, deenergization of the POS relay results in the closure of the normally closed POS1 contacts so that the relay MPR is again energized, closing the contacts MPR1, 2, and opening the contacts MPR3, 4. This restores the diameter-sensing circuit to its original state, ready for another cycle of operation. When relay PA is deenergized, its contacts PA3 reopen, thereby breaking the energization path for the contactor coil FOR, opening the contacts FOR1–3 (Fig. 1), and deenergizing the motor M so that the reel ceases rotation.

It will thus be seen from the foregoing description that the apparatus and controls of the present invention have operated, first, to sense a given diameter of the expiring roll 14A and to initiate all of the preliminary operations required of the web splicing apparatus, namely, the initial rotation of the reel assembly to position the new roll **14B** adjacent the running web W, the lowering of the predrive and paster carriages **55** and **76**, and the initiation of predriving of the new roll from the predrive motor PDM through the belt **60**. Then, in response to the expiring roll 14A reaching a second, smaller predetermined diameter, the brushes **74** were automatically caused to deflect the running web W against the adhesive on the leading end of the new roll web, and the knives **90** were caused to engage and sever the web drawn from the expiring roll **14A**. Following that the new roll **14B** is braked to create transition tension in the new web, the reel assembly **40** rotated clockwise to place the new roll **14B** in the normal operating position, and the predrive and paster carriages **55** and **76** raised to their stowed positions.

With the rotation of the reel assembly to place the new roll **14B** in the regular supply position, the slip rings **45** and **46** together with the mercury switches carried by the spider **42** connect the contact points CP1B and CP2B into the diameter-sensing circuits, and connect the contact points CP1C into the energization circuit for the relay F. Thus, the circuitry shown in Fig. 9 is ready to begin automatically another cycle of operation such as that previously described whenever the roll **14B**, which is now in the position in which it is designated "the expiring roll," reaches certain small diameters. All that the operator need do is to remove the core of the expired roll 14A which has now been shifted to the position illustrated for the newly loaded roll 14C in Fig. 1 and to place a new roll of paper on the spindles **44*a*** journaled in the arms **42*a***.

Whenever it is necessary to initiate and complete an automatic splicing operation, the apparatus as described above will carry that operation through completely automatically, without any attention or critical judgments on the part of the attendant and even though the press may be running at various speeds.

We claim as our invention:

1. In web splicing apparatus for splicing a running web drawn from an expiring roll to the web of a new roll, said apparatus having first components providing for effecting preliminary operations to make ready for splicing and having second components for effecting the splicing operation, the combination comprising means for sensing the angular velocity of the expiring roll and producing a first, recurring signal which has an asymmetrical wave form and a frequency which depends on said angular velocity, means for sensing the linear velocity of the running web and producing a second signal related thereto, means for comparing said signals at a time instant intermediate the beginning and ending of each waveform, means controlled by said comparing means for initiating the preliminary operations by said first components when the expiring roll is reduced to a first diameter, and means controlled by said comparing means for initiating the splicing operation by said second components when the expiring roll is reduced to a second, smaller diameter.

2. Apparatus for automatically splicing a running web drawn from an expiring roll to adhesive on the leading end of the web of a new roll, said apparatus comprising, in combination, means for predriving said new roll, means for deflecting said running web against said new roll and severing that web, means for positioning the new roll adjacent the running web, means for positioning said predrive means adjacent the new roll, means for positioning said deflecting and severing means adjacent the running web, means for sensing the angular velocity of the expiring roll and producing a first, recurring signal which has an asymmetrical wave form and a frequency which depends on said angular velocity, means for sensing the linear velocity of the running web and producing a second signal related thereto, means for comparing said signals at a time instant intermediate the beginning and ending of each waveform, means responsive to said comparing means for actuating said three positioning means and said predriving means when the expiring roll is reduced to a first diameter, and means responsive to said sensing means for actuating said deflecting and severing means when the expiring roll is subsequently reduced to a second, smaller diameter.

3. Apparatus for automatically splicing a running web drawn from an expiring roll to adhesive on the leading end of the web of a new roll, said apparatus comprising, in combination, means for supporting said rolls for rotation about parallel axes, means for bodily moving said supporting means to bring said new roll to a position adjacent the running web, a predrive carriage having means thereon for rotating said new roll, means for moving said predrive carriage from a stowed position clear of the path of movement of said rolls to a position adjacent said new roll, a paster carriage having web deflecting means and web severing means thereon, means for moving said paster carriage from a stowed position clear of the path of movement of said rolls to a position adjacent said running web on the opposite side thereof from said new roll, first and second pairs of contact points, means for opening and closing said first and second pairs of points at instants when the expiring roll passes through respectively different angular positions so that the period between the opening of said first points and the closing of said second points is inversely related to the angular velocity of the expiring roll, means for creating a voltage which repetitively decays substantially exponentially with time from the instants that said first points open, means for creating a voltage proportional in magnitude to the linear velocity of said running web, means for comparing said exponential and proportional voltages at the instants when said second contacts close, means controlled by said comparing means for actuating (*a*) said roll-support moving means, (*b*) said predrive carriage moving means, (*c*) said paster carriage moving means, and (*d*) said new roll rotating means when said exponetial voltage exceeds said proportional voltage at an instant when said second contacts close, means for then creating a voltage which repetitively decays substantially hyperbolically with time from the instants said first contacts close, means for then increasing the proportionally constant relating said proportional voltage to said running web velocity, means comparing said hyperbolic and increased proportional voltages at the instances said second contacts close, means controlled by said last-named comparing means for sequentially actuating said web-deflecting and web-severing means when said hyperbolic voltage exceeds said increased proportional voltage at the instant said second contacts close.

4. Apparatus for automatically splicing a running web drawn at any velocity within a range of velocities from an expiring roll to adhesive on the leading end of the web of a new roll, said apparatus comprising, in combination, means for rotatably supporting said rolls, means for bodily moving said rolls to bring said new roll to a position adjacent said running web, a predrive carriage and means for moving it from a stowed position clear of the path of movement of said rolls and a position adjacent the periphery of said new roll, means on said predrive carriage for rotationally driving said new roll, a paster carriage and means for moving it from a stowed position clear of the path of movement of said rolls and a position adjacent said running web, means on said paster carriage for deflecting the running web against the periphery of the new roll, means on said predrive carriage for severing the web drawn from the expiring roll, means for sensing the linear velocity of said running web, means for sensing the angular velocity of said expiring roll, means responsive to said two sensing means for actuating said roll-moving means, both said carriage-moving means, and said new roll driving means when said expiring roll is reduced to a first diameter which is substantially proportional to said web velocity, means responsive to said last-named means for modifying the input-output function of said angular velocity sensing means, and means responsive to said modified sensing means for causing said web deflecting and severing means to be actuated in sequence when said expiring roll reaches a second, smaller diameter which is independent of said web velocity.

5. In apparatus for splicing a running web drawn at different adjusted velocities from an expiring roll into a web-consuming device to an adjacent rotating new roll which has adhesive on the leading edge of its web, the combination comprising means for deflecting the running web against the surface of the new roll, means responsive to the actuation of said deflecting means for severing the web drawn from the expiring roll, means for sensing the angular velocity of said expiring roll and producing a recurring signal having an asymmetrical waveform and a frequency which depends on said angular velocity, means for sensing the linear velocity of said running web and producing a second signal related thereto, means for comparing said signals at a time instant intermediate the beginning and ending of each waveform, and means responsive to the comparing means for actuating said deflecting means when said expiring roll is reduced to a predetermined diameter which is independent of the adjusted web velocity.

6. In apparatus for splicing a running web drawn from an expiring roll into a web-consuming device to adhesive on the leading edge of the web of a rotating new roll which is adjacent the running web, the combination comprising means for deflecting the running web against the surface of the new roll, means responsive to actuation of said deflecting means for severing the web drawn from the expiring roll, first and second pairs of contact points, means for opening and closing said first and second points at instants when the expiring roll passes through first and second angular positions, respectively, means

for creating a first voltage which repetitively decays from a fixed value substantially hyperbolically with time from the instants that said first contact points open, means for creating a second direct voltage proportional in magnitude to the linear velocity of said running web, and means for actuating said deflecting means when said first voltage exceeds said second voltage at the instant that said second contact points close, so that the deflecting and severing actions occur automatically when said expiring roll has been reduced to a predetermined diameter.

7. In apparatus for splicing a running web drawn from an expiring roll into a web-consuming device to adhesive on the leading edge of the web of a rotating new roll which is adjacent the running web, the combination comprising means for deflecting the running web against the surface of the new roll, means responsive to actuation of said deflecting means for severing the web drawn from the expiring roll, first and second pairs of contact points, means for opening and closing said pairs of points at instants when the expiring roll passes through respectively different angular positions so that the period between the opening of the first points and the closing of the second points is inversely related to the angular velocity of the new roll, means for creating a signal which repetitively varies substantially hyperbolically with time during the periods between the opening of said first points and the closing of said second points, said last-named means including series-connected capacitor and resistor components adapted for connection to a direct voltage source, and means connecting said first points directly in parallel with said capacitor component, means for creating a direct voltage proportional in magnitude to the linear velocity of said running web, a current-responsive signaling device, a unidirectionally conductive device and means connecting said proportional voltage means, said signaling device, said unidirectionally conductive device, and said second points all in series across one of said components with said proportional voltage opposed in polarity to the voltage developed across said one component, and means responsive to actuation of said signaling device for actuating said web deflecting means.

8. In apparatus for splicing a running web drawn at an adjustable linear velocity from an expiring roll into a web-consuming device to a new roll which has adhesive on the leading edge of its web, the combination comprising means for moving the new roll to a position adjacent the running web, a predrive carriage and a paster carriage both shiftable between stowed and effective positions, means for sensing the angular velocity of said expiring roll and producing a recurring signal having an asymmetrical waveform and a frequency which depends on said angular velocity, means for sensing the linear velocity of said running web and producing a second signal related thereto, means for comparing said signals at a time instant intermediate the beginning and ending of each waveform, and means responsive to said comparing means for actuating said roll-moving means and shifting said carriages to their effective positions when said expiring roll is reduced to a diameter which is dependent on the adjusted linear velocity of the web.

9. In apparatus for splicing a running web drawn from an expiring roll into a web-consuming device to adhesive on the leading edge of the web of a new roll, the combination comprising means for rotatably supporting said rolls, means for bodily moving said rolls to bring said new roll to a position adjacent the running web, a predrive carriage and means for moving it from a stowed position clear of the path of movement of said rolls and a position adjacent the periphery of said new roll, means on said predrive carriage for rotationally driving said new roll, a paster carriage and means for moving it from a stowed position clear of the path of movement of said rolls and a position adjacent the running web, first and second pairs of contact points, means for opening and closing said first and second points at instants when the expiring roll passes through first and second angular positions, respectively, means for creating a first voltage which repetitively decays from a fixed value substantially exponentially with time from the instants that said first contact points open, means for creating a second direct voltage proportional in magnitude to the linear velocity of said running web, and means for actuating said roll-moving means and both said carriage-moving means when said first voltage exceeds said second voltage at the instant that said second contact points close, so that the apparatus is readied for a splicing operation automatically when said expiring roll has been reduced to a diameter related in predetermined fashion to the linear velocity of the running web.

10. In apparatus for splicing a running web drawn from an expiring roll into a web-consuming device to adhesive on the leading edge of the web of a rotating new roll, the combination comprising means for rotatably supporting said rolls, means for bodily moving said rolls to bring said new roll to a position adjacent the running web, a predrive carriage and means for moving it from a stowed position clear of the path of movement of said rolls to a position adjacent the periphery of said new roll, means on said predrive carriage for rotationally driving said new roll, a paster carriage and means for moving it from a stowed position to a position adjacent the running web, means on said paster carriage for deflecting the running web against the surface of said new roll and then severing the expiring roll web, first and second pairs of contact points, means for opening and closing said pairs of points at instants when the expiring roll passes through respectively different angular positions so that the period between the opening of the first points and the closing of the second points is inversely proportional to the angular velocity of the new roll, means for creating a signal which repetitively varies substantially exponentially with time during the periods between the opening of said first points and the closing of said second points, said last-named means including a series-connected capacitor component and resistor component adapted for connection to a direct voltage source and means connecting said first points directly in parallel with said capacitor component, means for creating a direct voltage proportional in magnitude to the linear velocity of said running web, a current-responsive signaling device, a unidirectionally conductive device and means connecting said proportional voltage means, said signaling device, said unidirectionally conductive device, and said second points all in series across one of said components with said proportional voltage poled oppositely to the voltage developed across said one component, means responsive to the energization of said signaling device for actuating (*a*) said roll-moving means, (*b*) said predrive carriage moving means, (*c*) said paster carriage moving means, and (*d*) said new roll driving means, so that said apparatus is readied for operation of said deflecting and severing means whenever the expiring roll reaches a diameter which is substantially proportional to the linear velocity of the running web.

11. For use with a rotating web roll onto which or from which a web is being wound or unwound, the combination comprising first and second pairs of contact points, means for opening said first and second points at instants when the roll passes through first and second angular positions, respectively, means for creating a first voltage which repetitively varies substantially exponentially with time from the instants that said first points open, means for creating a second voltage which is proportional in magnitude to the linear velocity of said web, a signaling device, means for first actuating said signaling device only if a certain one of said two voltages exceeds the other at an instant when said second contact points are closed thereby indicating that the roll has reached a first diameter, and means responsive to said actuation

of said signaling device for modifying said first voltage-creating means such that said first voltage thereafter repetitively varies substantially hyperbolically with time from the instants that said first contact points open, whereby said signaling device will be actuated a second time by said actuating means when the roll reaches a second, predetermined diameter.

12. For use with a rotating web roll from which a web is unwound at any one of a plurality of linear velocities, apparatus for sequentially signaling when the roll has reached (*a*) a first diameter related in predetermined fashion to the web velocity and (*b*) a second predetermined diameter independent of the web velocity, said apparatus comprising, in combination, first and second pairs of breaker points, means for opening and closing said first and second points at instants when the roll passes through first and second angular positions, respectively, a first resistor and a capacitor connected in series and adapted for connection to a direct voltage source, means connecting said first contacts in parallel with said capacitor, means for creating a direct voltage proportional in magnitude to the linear velocity of said web, a unidirectionally conductive device, a current-responsive signaling device, means connecting said proportional voltage, said unidirectionally conductive device, said second contact points, and said signaling device in series and the series combination across said first resistor with the proportional voltage opposed in polarity to the voltage developed across said first resistor and the unidirectionally conductive device poled to conduct only when the voltage across said first resistor exceeds said proportional voltage, a second resistor, means responsive to the first energization of said signaling device for changing the time constant of said resistor-capacitor series combination and for connecting said second resistor in parallel with said capacitor so that the voltage across said first resistor decays substantially hyperbolically with time from each instant that said first contacts open, and means responsive to the first energization of said signaling device for changing the proportionality factor of said velocity-proportional voltage.

13. Apparatus for signaling when a rotating roll upon which or from which a web is being wound or unwound has reached a predetermined diameter, said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said first and second pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of the first points and the closure of said second points is inversely related to the angular velocity of the roll, means for creating a voltage which repetitively varies in magnitude substantially hyperbolically with time from the instants that said first points open, means for creating a voltage proportional in magnitude to the linear velocity of said web, a signaling device, and means for actuating said signaling device when a particular one of said two voltages exceeds the other at the instants that said second contact points close.

14. Apparatus for signaling when a rotating roll upon which or from which a web is being wound or unwound has reached a predetermined diameter, said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said first and second pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of the first points and the closure of said second points is inversely related to the angular velocity of the roll, means for creating a voltage which repetitively varies in magnitude substantially hyperbolically with time from the instants that said first points open, means for creating a voltage proportional in magnitude to the linear velocity of said web, a current responsive signaling device, a unidirectionally conductive device, and means connecting in series relation said hyperbolically varying voltage, said proportional voltage, said unidirectionally conductive device, and said signaling device, the said two voltages being oppositely poled.

15. Apparatus for signaling when a rotating roll upon which or from which a web is being wound or unwound has reached a predetermined diameter regardless of the web velocity; said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of the first pair of points and the closing of the second pair of points is inversely related to the angular velocity of the roll; means for creating a voltage which varies substantially hyperbolically with time during the periods between the opening of said first pair of contacts and the closing of said second pair of contacts; said last-named means including a series-connected capacitor component and a resistor component adapted for connection to a direct voltage source, and means connecting said first pair of points directly in parallel with said capacitor component so that said hyperbolically varying voltage is developed across one of said components, means for creating a direct voltage proportional in magnitude to the linear velocity of said web, a current-responsive signaling device, a unidirectionally conductive device, and means connecting said proportional voltage means, said unidirectionally conductive device, said signaling device, and said second contacts all in series across said one component with said proportional voltage poled oppositely to the voltage developed across said one component.

16. Apparatus for signaling when a rotating roll from which a web is being unwound reaches a predetermined diameter regardless of the linear speed of the web, said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of said first points and the closing of said second points is inversely related to the angular velocity of the roll, means for creating a voltage which repetitively decays from a predetermined value in substantially hyperbolic relation with time from the instants that said first points open, means for creating a voltage proportional in magnitude to the linear velocity of said web, a signaling device, and means for actuating said signaling device when said hyperbolic voltage exceeds said proportional voltage at the instant said second contact points close.

17. Apparatus for signaling the reduction of an expiring web roll to a predetermined diameter, said roll being rotated as the web is drawn therefrom, said apparatus comprising, in combination, first and second pairs of contact points, means for closing and opening said pairs of points as the roll passes through respectively different angular positions during each revolution of said roll, means for creating a voltage which varies substantially hyperbolically with time during the periods between the opening of said first pair of contacts and the closing of said second pair of contacts; said last-named means including a circuit including a capacitor component and a resistor component in series and adapted for connection to a direct voltage source, and means connecting said first pair of points in parallel with said capacitor component so that said hyperbolically varying voltage appears across one of said components, means creating a direct voltage which is proportional to the linear velocity of the web, a current-responsive signaling device, a unidirectionally conductive device, and means for connecting said signaling device, said unidirectionally conductive device, said proportional voltage and said second pair of contacts in series across said one component with said proportional voltage poled oppositely to the voltage developed across said one component.

18. Apparatus for signaling the reduction of an expiring web roll to a predetermined diameter, said roll being

rotated as the web is drawn therefrom; said apparatus comprising, in combination, first and second pairs of contact points, means for closing and opening said pairs of points as the roll passes through respectively different angular positions during each revolution of said roll, means for creating a voltage which varies substantially hyperbolically with time during the periods between the opening of said first pair of contacts and the closing of said second pair of contacts, said last-named means including a circuit including a capacitor and a first resistor in series and adapted for connection to a direct voltage source, and a second resistor connected in parallel with said capacitor; means connecting said first pair of points in parallel with said capacitor component, means creating a direct voltage which is proportional to the linear velocity of the web, a current-responsive signaling device, a unidirectionally conductive device, and means for connecting said signaling device, said unidirectionally conductive device, said proportional voltage and said second pair of contacts in series across said first resistor with said proportional voltage opposed in polarity to the voltage developed across said first resistor, and said unidirectionally conductive device poled to conduct only when the voltage across said first resistor exceeds said proportional voltage.

19. Apparatus for signaling when a rotating roll upon which or from which a web is being wound or unwound has reached a diameter that is related in a predetermined manner to the linear velocity of the web, said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of the first points and the closure of the second points is inversely related to the angular velocity of the roll, means for creating a first voltage which repetitively varies in magnitude substantially exponentially with time from the instant that said first points open, means for creating a second voltage proportional in magnitude to the linear velocity of said web, a signaling device, and means for actuating said signaling device when a particular one of said two voltages exceeds the other at the instant said second contact points close.

20. Apparatus for signaling when a rotating roll upon which or from which a web is being wound or unwound has reached a diameter substantially proportional to the linear velocity of the web, said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said first and second pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of the first points and the closure of said second points is inversely related to the angular velocity of the roll, means for creating a voltage which repetitively varies in magnitude substantially exponentially with time from the instants that said first points open, means for creating a voltage proportional in magnitude to the linear velocity of said web, a current-responsive signaling device, a unidirectionally conductive device, and means connecting in series relation said exponentially varying voltage, said proportional voltage, said unidirectionally conductive device, and said signaling device, the said two voltages being oppositely poled.

21. Apparatus for signaling when a rotating roll upon which or from which a web is being wound or unwound has reached a diameter substantially proportional to the linear velocity of the web, said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of the first pair of points and the closing of the second pair of points is inversely related to the angular velocity of the roll, means for creating a voltage which varies substantially exponentially with time during the periods between the opening of said first pair of contacts and the closing of said second pair of contacts, said last-named means including a series-connected capacitor component and a resistor component adapted for connection to a direct voltage source, and means connecting said first pair of points directly in parallel with said capacitor component so that said exponentially varying voltage is developed across one of said components, means for creating a direct voltage proportional in magnitude to the linear velocity of said web, a current-responsive signaling device, a unidirectional conductive device, and means connecting said proportional voltage means, said unidirectionally conductive device, said signaling device and said second contacts all in series across said one component with said proportional voltage poled oppositely to the voltage developed across said one component.

22. Apparatus for signaling when a rotating roll from which a web is being unwound reaches a diameter directly related in a predetermined fashion to the linear velocity of the web, said apparatus comprising, in combination, first and second pairs of contact points, means for opening and closing said pairs of points at instants when the roll passes through respectively different angular positions so that the period between the opening of said first points and the closing of said second points is inversely related to the angular velocity of the roll, means for creating a voltage which repetitively decays from a predetermined value in substantially exponential relation with time from the instants that said first points open, means for creating a voltage proportional in magnitude to the linear velocity of said web, a signaling device, and means for actuating said signaling device when said exponential voltage exceeds said proportional voltage at the instant said second contact points close.

23. Apparatus for signaling the reduction of an expiring web roll to a diameter related in predetermined fashion to the linear velocity of the web, said roll being rotated as the web is drawn therefrom, said apparatus comprising, in combination, first and second pairs of contact points, means for closing and opening said pairs of points as the roll passes through respectively different angular positions during each revolution of said roll, means for creating a voltage which repetitively varies substantially exponentially with time during the periods between the opening of said first pair of contacts and the closing of said second pair of contacts, said last-named means including a circuit including a capacitor component and a resistor component in series and adapted for connection to a direct voltage source, and means connecting said first pair of points in parallel with said capacitor component so that said exponentially varying voltage appears across one of said components, means creating a direct voltage which is proportional to the linear velocity of the web, a current-responsive signaling device, a unidirectionally conductive device, and means for connecting said signaling device, said unidirectionally conductive device, said proportional voltage and said second pair of contacts in series across said one component with said proportional voltage poled oppositely to the voltage developed across said one component.

24. Apparatus for signaling the reduction of an expiring web roll to a diameter which is substantially proportional to the linear velocity of the web, said roll being rotated as the web is drawn therefrom, said apparatus comprising, in combination, first and second pairs of contact points, means for closing and opening said pairs of points as the roll passes through respectively different angular positions during each revolution of said roll, means for creating a voltage which varies substantially exponentially with time during the periods between the opening of said first pair of contacts and the closing of said second pair of contacts, said last-named means including a circuit including a capacitor and resistor in series and adapted for connection to a direct voltage source, and means connecting said first pair of points in parallel with said capacitor compo-

nent so that said exponentially varying voltage is developed across said resistor, means creating a direct voltage which is proportional to the linear velocity of the web, a current-responsive signaling device, a unidirectionally conductive device, and means for connecting said signaling device, said unidirectionally conductive device, said proportional voltage and said second pair of contacts in series across said resistor with said proportional voltage opposed in polarity to the voltage developed across said resistor, and said unidirectionally conductive device poled to conduct only when the voltage across said resistor exceeds said proportional voltage.

25. Apparatus for signaling when a rotating roll upon which or from which a web is being wound or unwound has reached a certain diameter comprising, in combination, means for repetitively measuring off time periods which are related in duration to the angular velocity of said roll, means for repetitively creating a signal which varies from a starting value in a predetermined fashion during each of said periods, means for creating a reference signal, a signaling device, and means for actuating said signaling device when a particular one of said signals exceeds the other at the end of one of said time periods.

26. The combination set forth in claim 25 further characterized in that said reference signal-creating means comprises means for making said reference signal substantially proportional to the linear velocity of said web.

27. Apparatus for signaling when a rotating roll upon which or from which a running web is being wound or unwound has reached a certain diameter proportional to the linear velocity of said web, said apparatus comprising, in combination, means for measuring off during each revolution of the roll a time period related in duration to the angular velocity of the roll, means for creating a signal which repetitively varies from a starting value in exponential relation with time during each such time period, means for creating a signal which is proportional to the linear velocity of said web, a signaling device, and means for actuating said signaling device when a particular one of said signals exceeds the other at the end of any one of said time periods.

28. Apparatus for signalling when a rotating roll upon which or from which a running web is being wound or unwound has reached a predetermined diameter which is independent of the linear velocity of said web, said apparatus comprising, in combination, means for measuring off during each revolution of said roll a time period which is related in duration to the angular velocity of the roll, means for creating a signal which varies from a starting value in hyperbolic relation with time during each such time period, means for creating a signal which is proportional to the linear velocity of said web, a signaling device, and means for actuating said signaling device when a particular one of said signals exceeds the other at the end of any one of said time periods.

29. In apparatus for splicing a running web drawn at an adjustable velocity from an expiring roll to adhesive on the leading end of the web of a new roll, the combination comprising means for creating two signals which vary respectively as functions of the angular velocity of said expiring roll and the linear velocity of said running web, means for comparing said two signals, means controlled by said comparing means for initiating preliminary operations of the apparatus when the expiring roll reaches a diameter dependent on said linear velocity, means for then modifying the input-output function of one of said signal-creating means, and means controlled by said comparing means for then initiating the actual splicing operation of said apparatus when said expiring roll is reduced to a diameter which is substantially independent of said linear velocity.

30. In web splicing apparatus for splicing a running web drawn at an adjustable velocity from an expiring roll to the web of a new roll, said apparatus having first components providing for effecting preliminary operations to make ready for splicing and having second components for effecting the splicing operation, the combination comprising means for creating two signals which vary respectively as functions of the angular velocity of said expiring roll and the linear velocity of said running web, means for comparing said signals and actuated when a particular one exceeds the other, means responsive to said comparing means for initiating the preliminary operations by said first components when the expiring roll is reduced to a first diameter which is approximately proportional to said linear velocity, means actuated by said responsive means for changing the input-output function of one of said signal-creating means, and second means then responsive to said comparing means for initiating the splicing operation by said second components when the expiring roll is reduced to a second, smaller diameter which is substantially independent of said linear velocity.

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UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,963,235 December 6, 1960

Arne V. Pedersen et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 37, for "face" read -- fact --; column 8, line 21, for "universely" read -- inversely --; line 26, for "includ ng a res stor" read -- including a resistor --; column 9, line 2, for "centain" read -- certain --; lines 33 and 34, for "predeterminad" read -- predetermined --; column 10, line 39, for "through" read -- though --; column 11, line 73, before the left-hand portion of the equation insert a minus sign; column 12, line 3, strike out "log"; line 5, the equation should appear as shown below instead of as in the patent:

$$\log n = -\log \frac{1}{n}$$

Signed and sealed this 13th day of June 1961.

(SEAL)
Attestest:

ERNEST W. SWIDER DAVID L. LADD

Attesting Officer Commissioner of Patents