

- [54] **PASTER ANTICIPATE CIRCUIT**
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[58] **Field of Search**..... 242/58.1, 58.2, 58.3,
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[56] **References Cited**

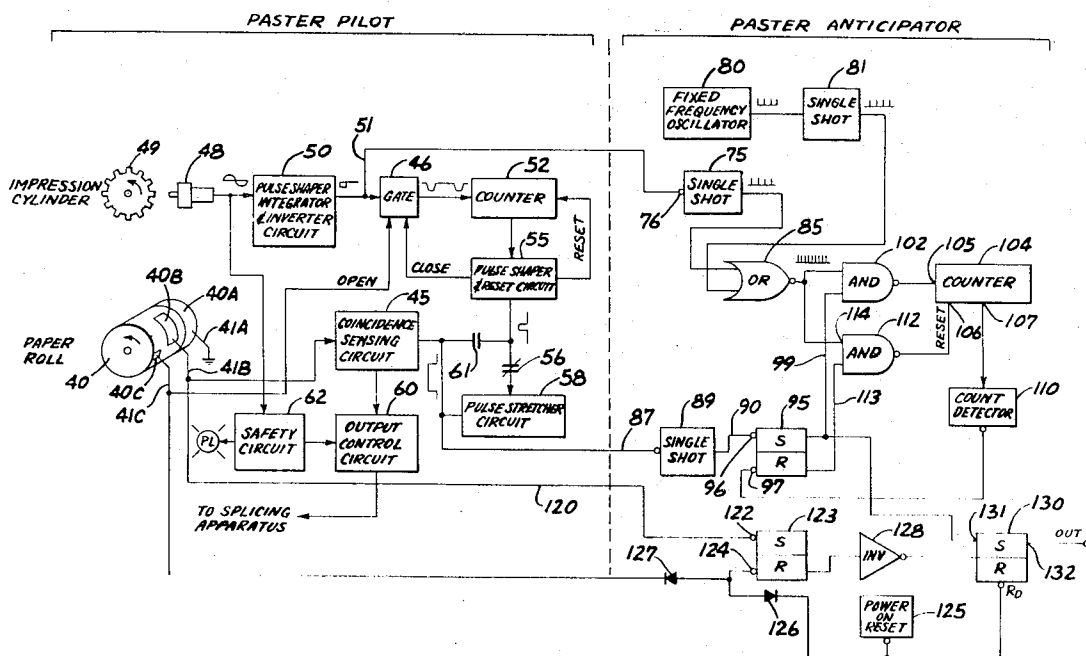
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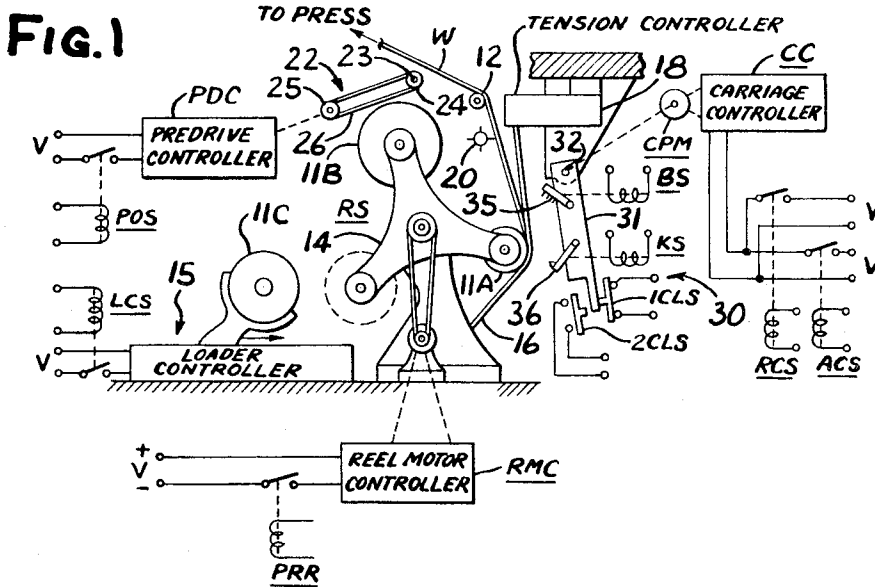
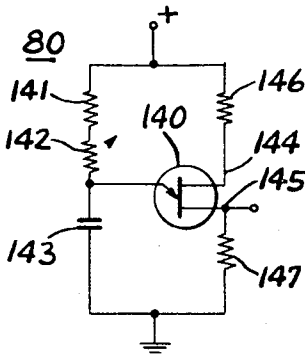
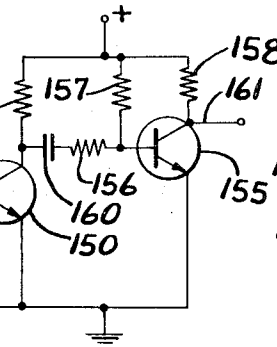
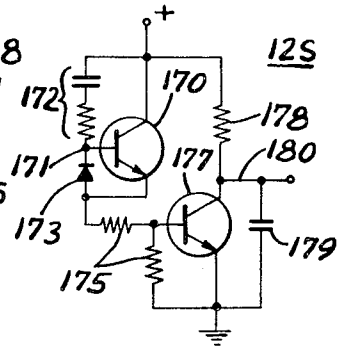
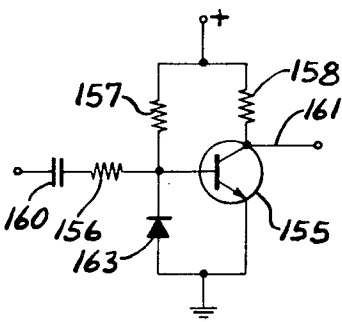
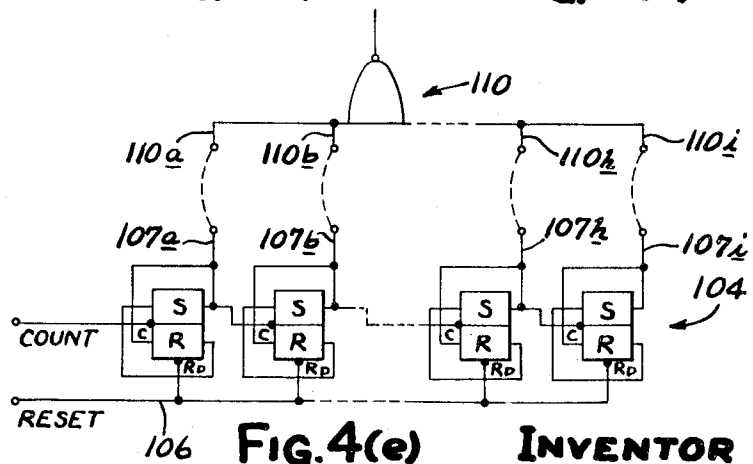
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[57] **ABSTRACT**

A digital control system for use with web fed printing presses or the like in which a new roll must be spliced to an expiring roll when the diameter of the expiring roll reaches a predetermined minimum and in which preliminary operations must be performed on the new roll in anticipation of the splicing operation. Disclosed is a method and apparatus for generating a signal to indicate that a predetermined period of time exists in advance of the start of preliminary operations, said period of time, once established, always remaining the same irrespective of the speed at which the web is running. Alternatively, the apparatus and method disclosed may provide an indication that a fixed period of time exists before the actual splicing operation.

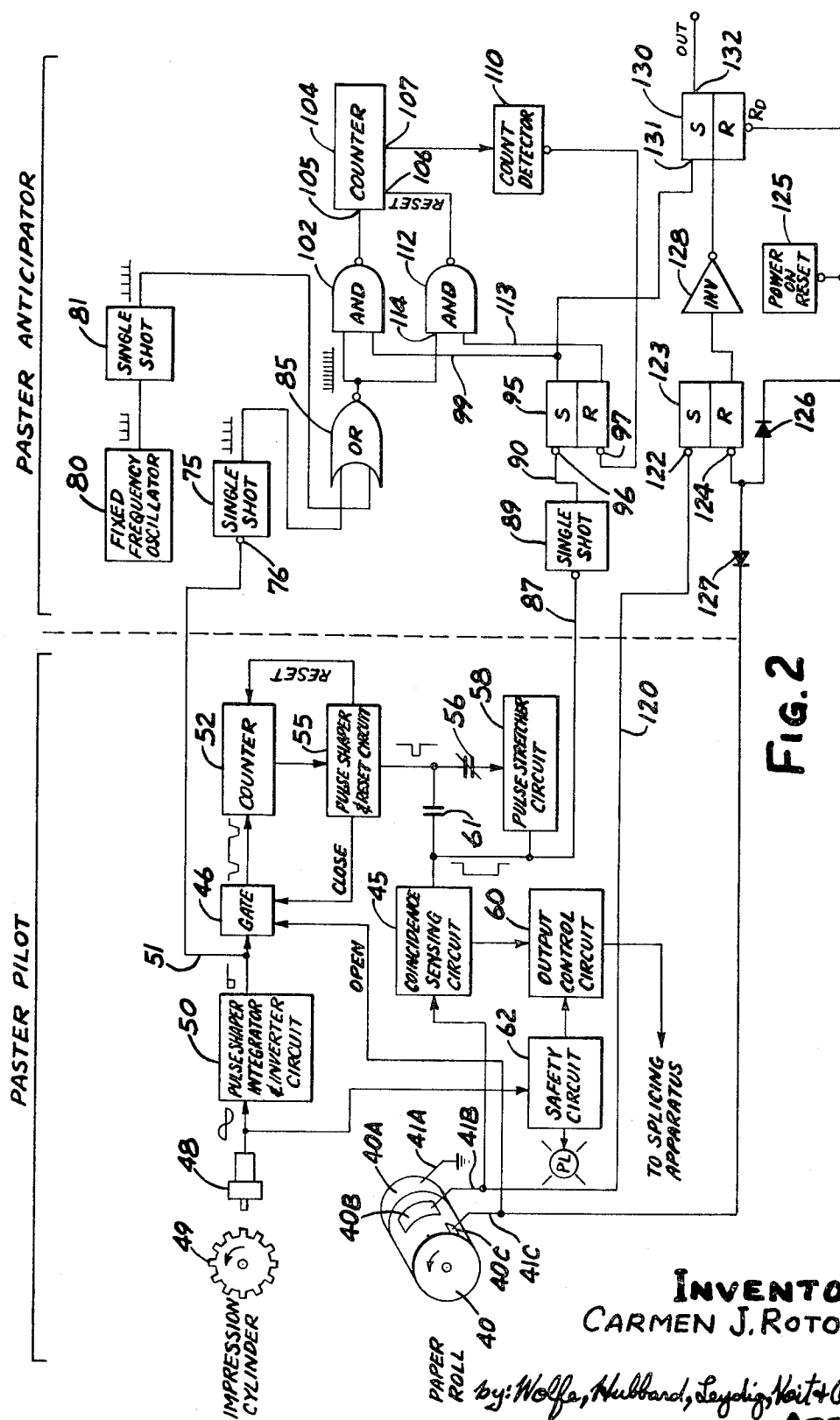
7 Claims, 9 Drawing Figures

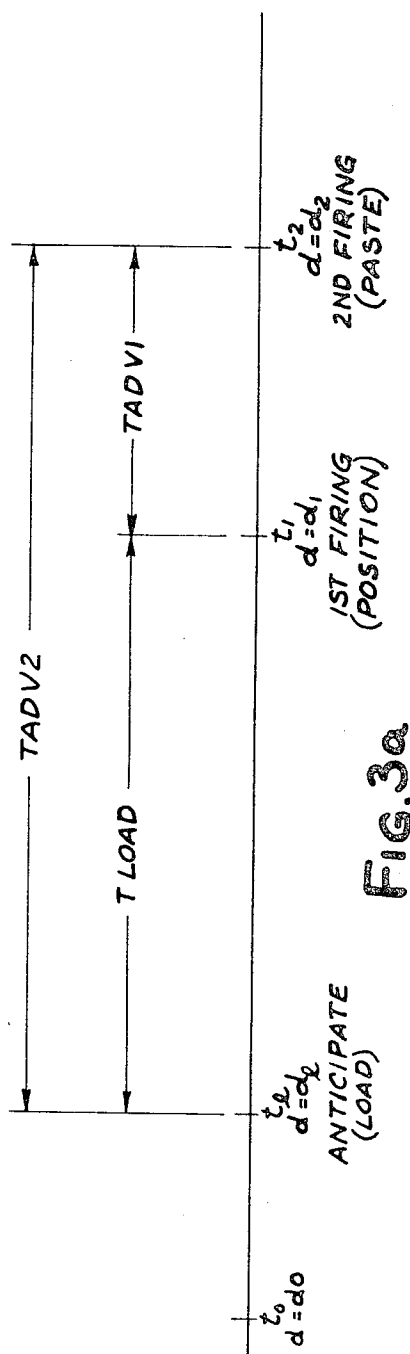
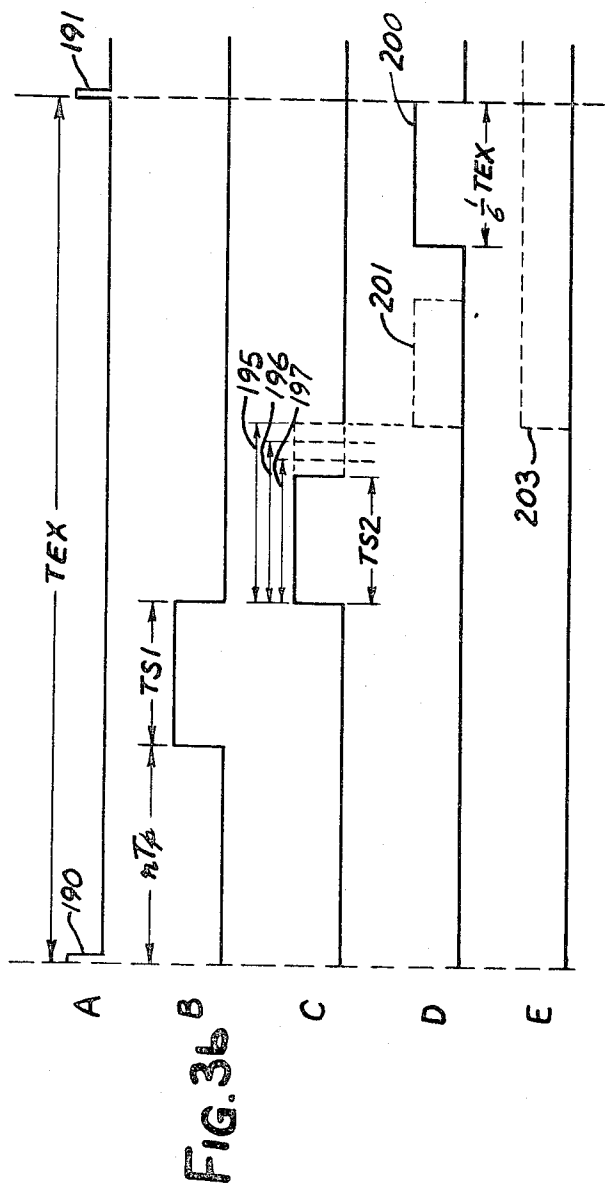




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PASTER ANTICIPATE CIRCUIT

This application is related to U.S. Pat. No. 3,317,153 of Frank A. Raymond issued May 2, 1967 and entitled "Digital Control System For Printing Presses Or The Like."

The present invention relates generally to digital control systems for controlling the feed of web to printing presses or the like and, more specifically, to a system for accurately controlling the time relationships between splicing a new web to an expiring roll, preparing the new roll for splicing, and loading another new roll in a standby position.

In a printing press of the type having a plurality of paper rolls on a reel the web of paper normally is fed into the press from one roll of paper until the roll diameter approaches the diameter of the core around which the paper is wrapped. The paper from a second roll on the reel then is spliced to the paper from the expiring roll while the press is operating to maintain a continuous web feed to the press. This entire operation, frequently referred to as making a paster, may be automatically controlled so that a minimum amount of paper remains on the core of the expiring roll at the completion of a splicing operation and so that the preliminary operations reach their completion as closely as possible to the splicing operation. The preliminary operations include, among other things, bringing the new web up to running speed and advancing the roll to the position for splicing. The automatic initiation of these preliminary operations can be accomplished by a digital control system such as that shown in U.S. Pat. No. 3,317,153 cited above. For several reasons it is also desirable to know the exact amount of time remaining before the preliminary operations begin so that other preliminary activities, such as loading a third roll into a standby position on the reel, can be completed before the preliminary operations begin.

Therefore, it is a primary object of the present invention to provide a paster control system for printing presses or the like producing an output control signal in advance of the preliminary operations on the new roll, said signal always occurring a fixed period of time in advance of the preliminary operations irrespective of the speed of the running web.

Another object of the present invention is the provision of a method for accurately anticipating, by giving a signal at a fixed advance time, the occurrence of an event which is related not to the time of roll expiration, but to the diameter of the expiring roll.

A further object of the present invention is the provision of a paster control system in which an indication is given when a fixed period of time exists before the splicing of the new roll to the web of an expiring roll regardless of the speed at which the web is moving.

Yet another object of the present invention is to provide an improved paster control system which is primarily digital in design, inherently reliable and economical.

Other objects and advantages of the present invention will become apparent upon reading the attached detailed description and upon reference to the drawings, in which:

FIG. 1 is a schematic diagram of a web-splicing apparatus;

FIG. 2 is a block diagram of a control system for the web splicing apparatus of FIG. 1, which system is constructed in accordance with the present invention;

FIGS. 3a and 3b are timing diagrams showing various time relationships for the circuitry shown in FIG. 2;

FIGS. 4a-4e are schematic diagrams of various circuits shown in block form in FIG. 2.

While the invention will be described in connection with certain preferred embodiments, it is to be understood that the invention is not to be limited to the particular embodiments set forth but, on the contrary, it is intended to cover the various modifications, alternatives, and equivalents as may be included within the spirit and scope of the invention.

In certain drawings digital circuit elements have been symbolically illustrated in the manner in which they are commonly used in the electronics art. In view of the common usage of these elements, it is unnecessary to give a detailed description of the combination of components constituting each logic element, and it will be readily appreciated by one skilled in the art that many different variations and combinations of components can be used to perform the logic function assigned to each circuit element. However, a brief description of the operation of these common elements will be helpful in understanding the operation of the digital control system of this invention. A flip-flop is a two stage multivibrator circuit having two stable states. In one state, the first stage is conducting and the second stage is cut off. In the other state, the second stage is conducting and the first stage is cut off. The flip-flops are illustrated as rectangles having two sections, one being marked S and the other being marked R. Input terminals are attached to the left side of the flip-flops, as illustrated in the drawings and output terminals are attached to the right side thereof. When an input signal or pulse is applied to the S input terminal, the flip-flop is "set" and the desired output signal is provided at the S output terminal only. When an input signal or pulse is applied to the R input terminal, the flip-flop is "reset" and the desired output signal is provided at the R output terminal only. A small circle at the input of a logic element indicates that the element responds to a negative going or ground signal at that input, whereas an uncircled input terminal indicates that the logic element responds to a positive going signal at that terminal. A small circle at the output terminal of a logic element indicates that the desired output signal will be negative-going or a logic 0, whereas an uncircled output indicates that the desired output signal will be positive-going. When an input signal or pulse is shown as applied to a terminal connected to the junction of the S and R sections, the element is intended to represent a "clocked" flip-flop, characterized by the fact that the stable state at the inputs of the S and R sections will be shifted to the outputs of the S and R sections respectively upon the occurrence of a "clock" pulse at the junction terminal. A "clocked" type flip-flop will act as a binary counter if the R output is connected to the S input and the S output is connected to the R input. With these cross-connections, the flipflop is "set" with each even numbered clock pulse at the common junction and "reset" upon the occurrence of each odd numbered pulse at the clock junction. Clocked flip-flops normally have an additional pair of input terminals S_d and R_d for directly setting or resetting the flip-flop without waiting for the occurrence of a "clock" pulse. In practice, a "set" flip-flop is said to be in the "one" state, while a reset flip-flop is in the "zero" state.

An OR gate, as used herein, produces a desired output signal in response to an input signal at any of its input terminals, while an AND gate produces a desired output signal only in response to input signals at all of its input terminals simultaneously. An inverter (INV) converts a positive-going signal into a negative-going signal and vice-versa. Finally, a single shot circuit such as a monostable multivibrator produces an output pulse of a predetermined width in response to an input of any width.

THE ENVIRONMENT FOR THE CONTROL SYSTEM

Referring now to the drawings and more specifically to FIG. 1, the invention is 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 an environment in which it may be employed. The apparatus shown is of the type disclosed in U.S. Pat. No. 2,963,235, issued Dec. 6, 1960, to A.V. Pedersen et al. and in U.S. Pat. No. 2,963,234, issued Dec. 6, 1960, to C.W. Chase et al., though the invention may be adapted by those skilled in the art to cooperate with various physical forms of splicing apparatus.

In general terms, a printing press (not illustrated) is powered by variable speed drive means such as an electric motor controlled by a suitable speed controller such that the speed may be manually adjusted to any value within a wide range. Turning now to FIG. 1, the press consumes a web W of paper which is drawn upwardly from an expiring roll 11A and passes over a guide roller 12, the press and related machinery being omitted from the present illustration. It will be apparent, nevertheless, that the linear velocity of the running web W depends upon the speed of the press as determined by the setting of the speed adjusting means associated therewith.

A reel stand RS is provided for supporting the expiring roll 11A and a new roll 11B. The reel stand includes a frame structure 13 and a rotatable spider assembly 14 having three uniformly distributed reel spindles. In the illustrated example, the expiring roll 11A is mounted on one spindle, the new roll 11B is mounted on a second spindle, and the third spindle is illustrated as being in position for acceptance of a second new roll 11C from a roll loader 15 or from any other means for loading a new roll, including manual loading.

In order to create tension in the web W and to insure its smooth passage upwardly into the press, an automatic tensioning system is provided to oppose the rotation of the expiring roll 11A. Briefly, the automatic tensioning system includes stationary friction straps 16 which engage the periphery of the expiring roll and are spaced apart over the axial length of the expiring roll 11A. The straps are anchored to the frame structure 13 of the reel stand and are kept taut by means of a pneumatic tension controller 18. The tension applied to the straps varies in accordance with the position of a floating guide roller (not shown), such position varying when the tension on the web W increases or decreases. Since the control of the web tension is conventional, and since such control does not constitute a part of the present invention, the automatic running tensioning system will not be described in further detail.

When the expiring roll 11A is about to expire, the leading end of the web on the new roll 11B is spliced

to the running web without slowing down the speed of the web running into the printing press. For the leading end of the web on the new roll 11B to be spliced to the running web W, the new roll 11B must be moved to a position in which its periphery is adjacent to the running web W and, subsequent to the splicing operation, the new roll 11B must be moved approximately to the position in which the expiring roll 11A is illustrated in FIG. 1 so as to engage the friction straps 16. For the purpose of moving the new roll 11B to successive positions, a reel motor RM, which is controlled by a reel motor controller RMC, is provided for rotating the spider assembly 14. The reel motor controller RMC in turn is controlled by operation of a position reel relay PRR which controls the supply of power to the reel motor controller, the controlled operation of the position reel relay PRR being set forth in the aforementioned Raymond patent.

In order to determine accurately and automatically when the new roll 11B has been translated to a position closely adjacent the running web W, a photoelectric device 20 may be mounted adjacent the running web W and associated with a light beam source so that the light beam will be broken by the periphery of the new roll 11B, and the photoelectric device 20 will be deactuated when the new roll has been driven to the desired position.

For the purpose of predriving or rotating the new roll 11B prior to the splicing operation in order that its peripheral speed will substantially match the linear velocity of the running web so that the web on the new roll is not severed when splicing occurs, predriving means are associated with the new roll 11B. Besides operating to predrive the new roll 11B, the predriving means are also employed in the present instance to retard the new roll immediately after a splicing operation so that tension is applied to the web running into the press during the transition period required for the new roll to be advanced into engagement with the friction straps 16. As illustrated, the predriving means include a predrive carriage 22 which is pivoted to swing about a shaft 23 between a raised or "stowed" position clear of the path of movement of the rolls supported by the reel stand RS and a lowered or "operative" position in which it is in operative contact with the new roll 11B. The carriage 22 journals pulleys 24 and 25 on either end over which is trained an endless predriving belt 26. When the carriage 22 is lowered to the operative position, the belt 26 engages the surface of the new roll 11B and, if the belt 26 is either driven or braked, it will serve to apply a driving or braking torque to the new roll 11B. For this latter purpose, the pulley 24 is drivingly connected with a predrive and braking motor (not illustrated) which is energized in a desired manner to properly control either its driving speed or its regenerative braking torque, the details thereof being set forth in the above-mentioned Pedersen et al. and Chase et al. patents.

In order to move or shift the predrive carriage 22 between its "stowed" and "operative" positions, a predrive controller PDC is provided. When rendered operative, the predrive controller PDC will either cause the carriage 22 to be swung counterclockwise or clockwise depending on whether the belt 26 is to be moved into engagement with the new roll or is to be moved out of engagement therewith. Operation of the predrive controller PDC is controlled by a predrive solenoid PDS

which causes power to be applied to the predrive controller when energized.

Once the new roll 11B has been moved to a position adjacent the running web W by rotation of the spider assembly 14 and the new roll 11B is predriven so that its peripheral speed substantially matches the linear velocity of the running web W, the actual splicing of the leading end of new web to the running web W is accomplished by the deflecting of 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, the adhesive pattern having axial discontinuities in the regions where the predrive belt 26 engages the new roll surface. The deflection of the running web W against the new roll web causes the leading end of the new roll web to adhere to the running web W and start traveling into the press.

For deflecting and then severing the running web W, a paster assembly 30 is provided which includes a carriage 31 pivotally supported on a shaft 32 to swing between a retracted or "stowed" position clear of the path of movement of the reel supported web rolls and a lowered or "operative" position adjacent the running web W on the opposite side thereof from the new roll 11B. For the purpose of driving the carriage 31 between the "stowed" and "operative" positions, a carriage positioning motor CPM is provided which is controlled by operation of a carriage controller CC. The carriage controller CC is in turn controlled by operation of an advance carriage solenoid ACS and a return carriage solenoid RCS which cause opposite polarity inputs to be applied thereto when energized. When the advance carriage solenoid ACS is energized, the carriage 31 will be advanced to the "operative" position and, when the return carriage solenoid RCS is energized, the carriage 31 will be returned to the "stowed" position. Moving the paster carriage 30 into position, plus positioning and predriving the new roll, are known as preliminary operations.

Supported by the carriage 31 is a brush assembly including a pivoted brush 25 for deflecting the running web W against the periphery of the new roll 11B in order that the adhesive on the leading end of the new roll web will adhere to the running web. For the purpose of moving the brush 35 into engagement with the running web W so as to impart deflecting movement thereto, a brush solenoid BS is provided which when energized imparts such movement to the brush 35. A knife assembly including a pivoted cutter or knife 36 is also provided on the carriage 31 for severing the old web drawn from the expiring roll 11A immediately after the brush assembly 35 has deflected the web against the glue pattern on the new roll 11B. For the purpose of moving the knife assembly 36 into severing engagement with the old running web, a knife solenoid KS is provided which imparts such movement thereto when energized.

For sensing the position of the carriage 31, a first carriage limit switch ICLS is mounted such that its actuator will be depressed and associated contacts will be closed by the carriage when the carriage is in "stowed" position. A second carriage limit switch 2CLS is mounted such that its actuator will be depressed and associated contacts will be closed by the carriage when the carriage is in the "operative" position.

The controlled operations of the advance carriage solenoid ACS, the return carriage solenoid RCS, the brush solenoid BS and the knife solenoid KS are set forth in detail in the Raymond patent mentioned previously.

The preliminary operations should be initiated when the expiring roll has a diameter which corresponds to a predetermined linear relationship 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 predescribed diameter. 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 angular roll velocity and linear web velocity are generated, compared, and utilized to initiate the preliminary operations when the signals timely overlap, i.e., portions thereof timely coincide.

After the preliminary operations are completed. The actual splicing is triggered when the expiring roll has been reduced to a predetermined diameter which remains at the preset value regardless of the adjusted value of the press speed. This is accomplished by the same signal generating apparatus mentioned above, but with one of the signal generating means being modified. Thus, two signals are again utilized to trigger the actual splicing operation when the signals timely overlap.

Referring now to FIG. 2, a control system is illustrated which is divided generally into two parts, a "paster pilot" circuit and a "paster anticipator" circuit. The Paster Pilot circuit is described more thoroughly in the Raymond patent, but a general description of this circuit is included herein.

THE PASTER PILOT CIRCUIT

The Paster Pilot is for initiating the preliminary operations and the splicing operations. For the purpose of producing a reference pulse during each revolution of the expiring roll, a commutator 40 is provided which is associated with the expiring roll, roll 11A as illustrated in FIG. 1. In the exemplary embodiment of the control system, the commutator 40 is so designed that (1) a reference pulse having a time period corresponding to a 60° sweep is provided during each 360° revolution of the commutator and the expiring roll and (2) a triggering pulse is provided at the termination of the 60° reference pulse sweep. For this purpose, three contact portions 40A-40C are provided on the commutator 40 which are engaged by brushes 41A-41C. Contact portion 40A is provided around the entire circumference of the commutator 40, contact portion 40B is provided over a 60° portion of the circumference, and contact portion 40C is provided over a short portion of the circumference adjacent the termination of the contact portion 40B. Since the brush 41A is connected to ground, a ground signal will be provided at brush 41B during each 60° sweep of the commutator 40 when the brush 41B is in engagement with the contact portion 40B and a ground signal will be provided at brush 41C when brush 41C engages the contact portion 40C. For ease of explanation, the beginning of contact portion 40B is arbitrarily designated as the 0° or 360° point in the circumference of the commutator 40.

The ground signal or reference pulse provided at the brush 41B is transmitted to a coincidence sensing circuit 45 for a purpose to be described hereinafter, and the ground signal provided at the brush 41C, i.e., the

triggering pulse, is transmitted to a gate 46 so that the gate is opened and pulses may be transmitted there-through. Accordingly, the reference pulse is produced between 0° and 60° of each commutator revolution and the narrow triggering pulse is produced at 60°.

Means are provided for producing timing pulses at a rate dependent upon the speed of the running web W including a magnetic pickup device 48 and a gear 49 mounted on the shaft of an impression cylinder (not shown). The magnetic pickup device 48 and the gear 49 are so associated that, as the gear rotates, the teeth thereof induce pulses in the magnetic pickup device.

The A-C output of the magnetic pickup device 48 is transmitted to a pulse shaper, integrator, and inverter circuit 50 which produces a pulse type output for each cycle of the A-C magnetic pickup device output. The output pulses in turn are transmitted to the input of the gate 46 which, when opened, allows the pulses to pass therethrough to the input of a counter 52. As previously mentioned hereinabove, the gate 46 is opened when a triggering pulse is produced in the brush 41C associated with the commutator 40. The output of the pulse shaper, integrator, and inverter circuit 50 is also associated with an auxiliary output terminal 51 for a purpose to be described hereinafter.

The counter 52 is preferably an eight stage binary scaler having logic gates connected to produce an output when a selected number of pulses have been counted thereby. Since, when the gate 46 is open, one pulse is applied to the counter 52 for each cycle of the A-C magnetic pickup device output, the count in the counter 52 corresponds to the number of teeth of the gear 49 which have passed the magnetic pickup device 48. Thus, when an output pulse is produced by the counter 52, it indicates that a prescribed reference length of the running web W has passed through the press.

The output of the counter 52 is transmitted to a pulse shaper and reset circuit 55 which, in response thereto, produces a reset pulse which is transmitted to the counter 52 to cause resetting thereof and produces a gate closing pulse which is transmitted to the gate 46 to cause closing thereof. Additionally, an output pulse or "control" pulse is produced by the pulse shaper and reset circuit 55 which is transmitted through a normally closed contact 56 to a pulse stretcher circuit 58 which in turn produces an output pulse having a preselected extended time period, i.e., a "stretched" pulse. The output of the pulse stretcher circuit is in turn transmitted to the coincidence sensing circuit 45. The pulse stretcher circuit 58 is preset to produce a "stretched" pulse having a constant time period regardless of the linear velocity of the running web W.

When the reference pulse produced by the commutator 40 and the "stretched" pulse produced by the pulse stretcher circuit 58 timely overlap, the coincidence sensing circuit 45 is rendered operative to provide an output pulse which is transmitted to an output control circuit 60. In response to the coincidence sensing circuit output, the output control circuit 60 operates to initiate the previously described preliminary operations of the splicing apparatus illustrated in FIG. 1. Additionally, the output control circuit 60 operates to open the normally closed contact 56 and to close the normally open contact 61 so that the output of the pulse shaper and reset circuit 55 is no longer connected through the pulse stretcher circuit 58 to the coincidence sensing

circuit 45, but rather is connected directly to the input of the coincidence sensing circuit 45, i.e., the pulse stretcher circuit is rendered ineffective. Subsequently, when the reference pulse produced by the commutator 40 and the control pulse produced by the pulse shaper and reset circuit 55 timely overlap, the coincidence sensing circuit 45 is rendered operative to produce an output pulse which is transmitted to the output control circuit 60. In response to this coincidence sensing circuit output pulse, the output control circuit 60 operates to initiate the splicing operation of the apparatus illustrated in FIG. 1. It should be noted that the time of coincidence as well as the reference length of web W may be changed by changing the preset count in counter 52.

For the purpose of insuring against false operation of the control system when the expiring roll is manually displaced during a "jogging" operation a safety circuit 62 is provided for rendering the control system inoperative when the press is not running. Additionally, the safety circuit 62 controls operation of a paster pilot indicating light PL.

From the foregoing, it is seen that the paster pilot circuit generates a first pulse to initiate the preliminary operations when the commutator 40 reaches a speed such that 5/6 of a revolution thereof occurs within the period of 1 stretched pulse plus the counting time of a predetermined number of pulses generated by the pickup 48. The circuit generates a second output pulse for initiating the splicing operation when 5/6 revolution of the commutator 40 is completed during the counting time alone, the time difference between the preliminary operations and the splicing operations being determined by the pulse stretcher circuit 58. The timing relations can be more clearly understood by reference to the aforementioned Raymond patent, which provides timing diagrams in FIGS. 4-8 plus appropriate description thereof.

PASTER ANTICIPATOR

In accordance with the present invention, there is provided additional circuit means for generating another output signal which occurs a fixed period of time in advance of the preliminary operations described above. This result is achieved by combining with the paster pilot circuit previously described an "anticipator" circuit utilizing certain signals already present in the paster pilot circuit plus certain additional signals for implementing a mathematically derived relationship for generating the desired output signal a fixed period time in advance of the preliminary operations. For a full understanding of the operation of the present invention an understanding of the mathematics behind the physical embodiment to be described is necessary. For the purposes of the following description, the term "first firing" refers to the output pulse from the paster pilot circuit for initiating the preliminary operations described above. The term "second firing" refers to the output pulse from the paster pilot circuit for initiating the splicing (paste) operation.

As noted above, the second firing signal is generated in the paster pilot circuit by a comparison of the length of time it takes to count a predetermined number of pulses related to press speed with the time it takes for 5/6 of a revolution of the expiring roll. The first firing (i.e., preliminary operations) signal is generated in advance of the second firing and represents a comparison of the duration of a constant stretched pulse from the

stretcher circuit 58 in addition to the time required for the counter 52 to reach its predetermined count with the time of 5/6 of a revolution of the expiring roll. It is the function of the present invention to produce a signal in advance of the first firing by a given amount of time such that this time will remain constant regardless of press speed. The manner in which this is accomplished is by adding to the constant stretched pulse in the paster pilot circuit a variable stretched pulse and comparing the total time with the time of 5/6 revolution of the expiring roll. In other words, the paster anticipator circuit compares the time required for 5/6 revolution of the expiring roll with the time required for three successive operations including (1) the counting of a predetermined number of pulses in the counter 52 of the pilot circuit, (2) the generating of the stretched pulse of a fixed duration from the stretcher circuit 58 and (3) the generating of a variable stretched pulse from the paster anticipate circuit shown in FIG. 2.

First we will derive the advance time TADV1 required for the preliminary operations, which is the time between the first and second firing pulses. For purposes which will later become clear the advance time TADV1 will be derived as a function of pulse stretcher time TS1. Consider the side view of a running roll. Furthermore, consider how the area of the view changes as the roll diameter decreases.

Let th = thickness of the paper in inches.

a = rate of area decrease in in^2/sec .

$A(t)$ = area of the roll at time t in in^2 .

V = linear velocity of the web in in./sec .

then,

$$a = th V \text{ (in}^2/\text{sec.)}$$

Consider FIG. (3a), where

d = roll diameter at time t in inches.

do = initial roll diameter at time t_0 in inches

then,

$$A(t) = \pi(do/2)^2 - a(t-t_0) = \pi(d/2)^2 \quad (1.2)$$

Substituting Equation (1.1) and solving for t yields

$$t = t_0 + (\pi/4 th V) (do^2 - d^2) \quad (1.3)$$

Let Tex = time of 1 revolution of the expiring roll in sec.

thus,

$$Tex = \pi d/V$$

by definition within the Digital Paster Pilot

$$n = 32 d_2 \quad (1.5)$$

where, n = the number of pulses counted by the pilot before it produces an output

d_2 = final roll diameter at time t_2 in inches

Let Tp = period of the pulses derived from the magnetic pickup in the pilot

then, the second firing of the pilot occurs when $d = d_2$ and $t = t_2$; thus,

$$n Tp = (5/6) Tex = 5\pi d_2/6V \quad (1.6)$$

The first firing of the pilot occurs when $t = t_1$ and $d = d_1$; thus

$$n Tp + TS1 = (5/6) Tex = 5\pi d_1/6V \quad (1.7)$$

where $TS1$ = the constant stretched counter output pulse in the pilot

Substituting Equation (1.6) in Equation (1.7) and solving for d_1 yields

$$d_1 = d_2 + 6V TS1/5\pi \quad (1.8)$$

From Equation (1.3)

$$t_2 = t_0 + (\pi/4th V) (d_0^2 - d_2^2) \quad (1.9)$$

$$t_1 = t_0 + (\pi/4th V) (d_0^2 - d_1^2) \quad (1.10)$$

$$\text{Letting, } TADV1 = t_2 - t_1 \quad (1.11)$$

and substituting Equations (1.8), (1.9) and (1.10) in (1.11) yields,

$$TADV1 = (9V TS1^2)/(25 th \pi) + (3 d_2 TS1)/5 th \quad (1.12)$$

The relationship between V in inches/sec and IPH is

$$V = C IPH/3600 \quad (1.13)$$

where,

C = sheet cutoff in inches.

IPH = press speed in impressions per hour

Thus substituting Equation (1.13) in Equation (1.12) yields,

$$TADV1 = (C IPH TS1^2)/(th \pi 10^4) + (3 d_2 TS1)/5 th \quad (1.14)$$

which is the desired result. It should be noted this derivation assumes that the velocity and therefore press speed is a constant in the time interval of $TADV1$. It is seen that if $TS1$, d_2 , th and C are given constant values, $TADV1$ is linearly related to press speed.

In accordance with the teachings of the present invention a second advance time $TADV2$ was sought which would remain constant in advance of the first firing signal regardless of press speed. The primary purpose of the advance signal $TADV2$ is to inhibit a loading sequence from starting if there would not be enough time to finish the sequence before the next preliminary operation. This form of loading initiation will, in effect, establish priorities for roll loading several different reels from one distributor-loading system, the priority of loading being dependent upon the order in which

preliminary operations begin for the various reels. The constant time sought is called TLOAD, and

$$TLOAD = TADV2 - TADV1$$

(2.1)

where, $TADV1$ corresponds to the first firing of the Digital Paster Pilot and $TADV2$ is $TLOAD$ seconds prior to $TADV1$ as shown in FIG. 3a. From Equation (1.14)

$$TADV2 = (C IPH (TS1 + TS2)^2) / (\pi th 10^4) + [3d_2 (TS1 + TS2)] / 5 th$$

(2.2)

where $TS2$ is the period of a "variable stretched pulse" generated in addition to $TS1$, the stretched pulse used in the pilot. Substituting Equation (1.14) and Equation (2.2) in Equation (2.1) yields,

$$TLOAD = TS2^2 [C IPH] / [\pi th 10^4] + TS2 [(3d_2) / (5th) + (2 TS1 C IPH) / (\pi th 10^4)]$$

(2.3)

The paster anticipate circuit of the present invention produces a signal representing the variable stretched pulse $TS2$ and senses coincidence of that pulse with the commutator pulse generated in the pilot during each revolution of the expiring roll.

When Equation 2.3 is solved for $TS2$ and $TS2$ is plotted against press speed with a constant $TLOAD$, the resulting curve gives the impression that $TS2$ is hyperbolically related to press speed. In actuality, the plot of $TS2$ vs. press speed is in the nature of a shifted hyperbola. Such a relationship can be approximated mathematically by the expression

$$TS2 \approx N / (f_p + f_o)$$

(2.4)

where N is a constant, f_p is proportional to press speed IPH and f_o is a constant term with the same dimensions as f_p .

The Equation 2.4 above, therefore, is an approximation equation derived from a study of $TS2$ as a function of press speed. This equation forms the basis for the circuit implementation represented by the paster anticipate circuit shown in FIG. 2. From equations 1.5, 1.6 and 1.13, it can be found that

$$f_p = 1/T_p = (4 C IPH) / (375 \pi)$$

(2.5)

and represents pulses derived from the magnetic pick-up 48 of the paster pilot circuit. The units of f_p will be pulses per second. Therefore, the constant term desired f_o takes the form of a constant frequency input derived from an oscillator in the circuit. The constant term N of equation 2.4 will then be the number of pulses to be counted from the two independent sources f_p and f_o . In other words, a signal representing the term $TS2$, the variable stretched pulse, can be generated by producing after the fixed stretched pulse $TS1$ a signal generated by counting a predetermined number N of pulses from two independent sources f_p and f_o . Just as the first firing pulse and second firing pulse were generated by detecting the coincidence of the stretched pulse from the circuit 58 and the counter pulse from the circuit 55

with the commutator pulse from the contact 40b, so also is the variable stretched pulse $TS2$ compared with the commutator pulse generated from the contact 40b of the commutator 40.

Briefly reviewing, the basic approach taken to providing a pulse which anticipates the preliminary operations by a fixed period of time involved an analysis of how the first firing pulse was obtained. This was obtained by adding to the output from the counter in the pilot circuit a constant stretched pulse, and detecting coincidence between this constant stretched pulse and a commutator pulse generated at the end of each revolution of the commutator. By adding an additional stretched pulse to the constant stretched pulse and detecting coincidence between the additional pulse and the commutator signal, a still further time in advance of the paste operation or first firing could be obtained. However in contrast to the constant stretched pulse used for the first firing, the second stretched pulse had to vary with press speed. This was necessary because the time between the first and second firing pulses varied with press speed, and the additional stretched pulse would be initiated by a signal which itself was dependent upon press speed. After having mathematically developed an expression relating the occurrence of the first firing pulse to press speed and to the constant width of the pilot stretched pulse, an expression relating to the new advance time $TADV2$ was derived incorporating the variable stretch pulse period $TS2$. With the primary objective of keeping the new advance time $TADV2$ constant with relation to the time $TADV1$ of the first firing pulse, an expression for the variable stretched pulse $TS2$ was developed as a function of press speed. This resulted in the shifted hyperbolic relationship represented by Equation 2.4.

The Paster anticipator circuit of FIG. 2 generates the variable stretched pulse $TS2$ and detects coincidence of this pulse with the commutator pulse in the pilot. For the purpose of producing timing pulses representing f_p at a rate proportional to the speed of the running web, one input signal to the paster anticipator circuit is taken from the output lead 51 from the pulse shaper, integrator and inverter circuit 50 of the paster pilot. This signal is fed through a single-shot multivibrator 75 having an input terminal 76 which is responsive to the negative-going edge of the timing pulses from the lead 51. The output from the multivibrator 75 is in the form of sharply defined narrow pulses. For simulating the constant frequency term f_o from the Equation 2.4 there is provided a fixed frequency oscillator 80, the output from which is in the form of narrow voltage spikes. These voltage spikes are fed through a single-shot multivibrator 81 which generates an output pulse of a width approximately equal to that of the single-shot multivibrator 75. The outputs from the multivibrators 75, 81 are applied to an inverting OR gate 85, the output from which represents the term $(f_p + f_o)$ from Equation 2.4. Since the variable stretched pulse $TS2$ is to be added to the constant stretched pulse from the circuit 58, the constant stretched pulse is taken from the paster pilot circuit on output line 87 and fed into a single-shot multivibrator 89 which produces an output pulse on line 90 on the trailing edge of the constant stretched pulse on line 87. The pulse from the multivibrator 89 is narrow in width and is fed to a flip-flop 95 having S and R input terminals 96, 97 respectively which are responsive to negative-going pulses. The flip-

flop 95 provides a gating signal on the line 99 to activate an inverting AND gate 102 which controls the input to an anticipator counter 104. The counter 104 may take any one of many forms well known in the art for binary counters, the only requirement being that an input terminal 105, a reset terminal 106 and output lines 107 from each stage be provided. The output leads 107 are fed to a count detector circuit 110 which may provide for a constant or variable counts and which, in either case, determines the constant N for the Equation 2.4. The counter and counter detector will be described in more detail below.

The output from the count detector 110 is a negative-going pulse signaling the end of the stretched pulse period $TS2$ of Equation 2.4. This pulse is applied to the reset input terminal 97 of the flip-flop 95. The reset output from the flip-flop 95 is connected to control a second inverting AND gate 112 via an input line 113 thereof. The other input line 114 to the AND gate 112 carries the output signal from the inverting OR gate 85 described above. The output from the gate 112 controls the reset terminal 106 of the counter 104. Therefore, when the flip-flop 95 is reset at the end of the variable stretched pulse, the AND gate 102 is closed to prevent further counting in the counter 104 while the AND gate 112 is opened to pass a reset signal to the terminal 106 of the counter 104, resetting all stages of the counter in preparation for the next counting operation.

From the above it is seen that the flip-flop 95 is set only during the period $TS2$ and reset at all other times. Therefore, the pulse at the S output terminal is a measure of $TS2$. The remaining function to be provided by the paster anticipator circuit is the detection of coincidence between the pulse $TS2$ and the commutator output pulse from the contact segment 40b of the commutator 40. To this end, an output line 120 is provided from the commutator output terminal 41b. The line 120 feeds the S input terminal 122 of a flip-flop 123, while the R input terminal 124 thereof is connected through a steering diode 126 to the output of the power-on reset circuit 125. An inverter circuit 128 inverts the signal from the R output terminal of the flip-flop 123 and provides a clock pulse to a clocked flip-flop 130 having an S input terminal 131, an S output terminal 132 and a direct reset terminal Rd. The S input terminal 131 is connected to receive the variable stretched pulse $TS2$ from the S output terminal of the flip-flop 95. The R input terminal 124 of flip-flop 123 is also coupled to the contact segment 40c through a steering diode 127. With this configuration, flip-flops 123 and 130 will be reset by a narrow pulse from the power-on-reset circuit 125 upon the application of power. Thereafter the flip-flop 234 will be alternately set and reset during each revolution of the commutator 40, going from reset to set as the contact segment 40b makes contact with the brush 41b. At this time the R output terminal from the flip-flop 123 is negative-going, creating a positive-going signal at the output of the inverter 128 sufficient to clock the flip-flop 130. If the variable stretched pulse $TS2$ is then present at the S input terminal 131, the flip-flop 130 will switch to the set state, producing an output on the terminal 132 to indicate that the desired fixed period of time now remains before the first firing of the paster pilot circuit.

Certain of the circuits shown in the paster anticipate circuit of FIG. 2 are shown in more detail in FIGS.

4a-4e. Shown in FIG. 4a is a simple uninjunction oscillator which may be used for the fixed frequency oscillator 80 of FIG. 2. This circuit includes a uninjunction transistor 140, the input to which is controlled by RC timing circuit consisting of a fixed resistor 141, a variable resistor 142 and a charging capacitor 143. A pair of base leads 144, 145 are connected respectively to a dropping resistor 146 and a load resistor 147, with the output being taken from the base lead 145. As the capacitor 143 charges beyond the firing threshold of the uninjunction transistor 140, the transistor 140 momentarily initiates conduction through the resistors 146 and 147 and also discharges the capacitor 143, creating a positive voltage spike at the output terminal 145. When the capacitor 143 is discharged below a certain voltage, the transistor 140 stops conducting until the capacitor 143 again charges to the firing threshold. The frequency of the oscillator can be varied with the variable resistor 142, which changes the rate of charge of the capacitor 143.

A circuit typical of the non-inverting single-shot 81 of FIG. 2 is shown by FIG. 4b. In this circuit a first transistor 150 of the NPN variety has a pair of input resistors 151 and 152 connected to its base. A collector load resistor 153 is connected to the positive supply. A second transistor 155 has a bias resistor 157 plus a collector load resistor 158. The emitters of both transistors 150 and 155 are grounded. A timing capacitor 160 and timing resistor 156 determine the width of the output pulse on lead 161. In operation, the second transistor 155 is normally conducting while the first transistor 150 is normally cut off. On the occurrence of an input pulse through the resistor 151, the transistor 150 is rendered conductive, short circuiting the input of the second transistor 155 to ground, momentarily rendering the second transistor non-conductive and causing the voltage at the output terminal 161 to rise. As the capacitor 160 charges, the transistor 155 is again rendered conductive and the voltage at the terminal 161 falls.

FIG. 4c shows an inverting one-shot circuit which operates in a manner identical to the second stage of the circuit of FIG. 4b, the only addition to the circuit being a protection diode 163 for preventing excessive reverse bias to the base-emitter junction of the transistor 155. The transistor 155 is normally conductive and the output terminal 161 is normally at a low voltage. A negative-going input pulse will momentarily render the transistor 155 non-conductive, with the transistor 155 resuming conduction only after the capacitor 160 has become sufficiently charged. The single-shot circuit of FIG. 4c is suitable for circuits 75 and 89 of FIG. 2.

FIG. 4d shows the details of the power-on reset circuit 125 of FIG. 2. In this circuit a first transistor 170 has an input terminal 171 coupled to the positive supply through an RC charging circuit 172. A protection diode 173 limits the reverse bias which might be applied to the base-emitter junction. The collector of the transistor 170 is tied directly to the positive supply while the emitter is coupled to the input circuit 175 of a second transistor 177. A dropping resistor 178 couples the collector of the second transistor 177 to the positive supply, while a damping capacitor 179 is connected from the collector to ground. As the power to the circuit is applied, the transistor 170 is rendered conductive by the charging circuit 172, which is initially uncharged. Bias current is conducted through the collector-emitter path of the first transistor 170 to ren-

der the second transistor 177 conductive, causing its output terminal 180 to assume a potential near ground. In the circuit of FIG. 2, this initial ground potential will reset the flip-flops 123 and 130. In the meantime the capacitor of the charging circuit 172 is charging and eventually insufficient current is carried therethrough to keep the transistor 170 in a conducting state. Both transistors 170 and 177 become non-conductive, and the voltage at the output terminal 180 rises toward the positive supply voltage. Having provided its initial 0 volt pulse, the power-on reset circuit 125 now remains non-conductive until the next time the power is turned on.

FIG. 4e illustrates a basic ripple counter which may be used for the counter circuit 104 of FIG. 2 and a single gate which may act as the count detector 110 of FIG. 2. The number of stages in the counter will vary depending upon the maximum count desired, with the present embodiment employing nine stages to generate possible counts of 0-511. Because of the feedback connections around each stage, the flip-flops shown in FIG. 4e are in a J-K configuration, an arrangement which inherently provides division by two with each successive stage, such that nine stages will provide division by 2⁹ or 512. The actual count detected from the possible 512 counts is determined by the inputs chosen for the count detector 110. The count detector 110 is in the form of an inverting AND gate having input terminals 110a-110i. The counter 104 has the S output terminals from each stage brought out to terminals 107a-107i respectively. As will be readily appreciated by one skilled in the art, any desired count can be detected by suitable connections between the input leads 110a-110i of the counter. The counter is reset by a negative-going pulse at the reset line 106, which in the present instance occurs in response to detection of the desired count in the detector 110.

The operation of the paster anticipate circuit of the present invention will be better understood by reference to FIG. 3b, which shows the fundamental timing relationships involved. The time for one revolution of the expiring roll is represented as TEX on curve A as defined by successive pulses 190, 191 generated by contact segment 40c of the commutator 40. The period nT_p represents the time period required for counting n pulses in the counter 52 of the paster pilot circuit. The period TS1 is, of course, the duration of the constant stretched pulse in the paster pilot. The period TS2 of the variable stretched pulse generated by the paster anticipate circuit is shown in curve C. This pulse is initiated by the trailing edge of the constant stretched pulse of curve B. The period TS2 will vary for different press speeds, as represented by the various pulse widths 195-197. Curve D shows the "second commutate pulse" 200 generated by the contact segment 40B of the commutator. A phantom pulse 201 on curve D represents the second commutate pulse generated at a later time as the press depletes the expiring roll. The coincidence of the latter pulse 201 with the stretched pulse TS2 of width 195 results in an output pulse 203 (curve E) being generated at the output terminal 132 of the paster anticipate circuit.

The following table illustrates the constancy of the values for TLOAD for various press speeds. The constants used in the examples represented by the table are as follows:

$n = \text{the preset count in the pilot counter} = 144$

$N = \text{the preset count in the anticipator counter} = 321$
 $f_o = 3.24 \text{ KHz}$
 $C = 23.563 \text{ inches}$
 $th = 0.003 \text{ inches}$
 $d_2 = 4.5 \text{ inches}$
 $TS1 = 32.1 \text{ milliseconds (constant)}$

IPH	10,000	30,000	50,000
TS2 (ms)	79.5	56.9	44.3
t ₁ (sec)	-31.5	-36.6	-41.8
t ₂ (sec)	-0	-0	-0
t ₂ (sec)	-131.5	-139.8	-142.2
TLOAD (sec) =			
t ₂ -t ₁ =	100.0	103.2	100.4

It is seen from the above table that in a nominal situation as described above the value of TLOAD remains constant within a 4 percent range for press speeds varying from 10,000 IPH to 50,000 IPH. This is well within the acceptable performance levels for press applications.

From the foregoing, it is seen that the digital control system herein disclosed produces a pair of output signals separated by a predetermined fixed period of time. The paster pilot circuit generates an output signal to initiate the preliminary operations when the circuit senses that the length of the running web drawn from the expiring roll during a fractional portion of each revolution of the expiring roll has reached a prescribed minimum value, the fractional portion of each revolution being determined by the time interval between successive commutator pulses adjusted by a fixed time period established by the pulse stretcher circuit. However, prior to this preliminary operations signal the paster anticipator circuit, which is integrally associated with the paster pilot circuit, produces another output signal when the length of the running web drawn from the expiring roll during a second fractional portion of each revolution reaches a prescribed minimum value. The time required for this second fractional portion is defined by the time required for the previously defined fractional portion adjusted by a period of time which varies as a nonlinear function of web speed. The output signal from the paster anticipator circuit is characterized by the fact that it occurs a fixed period of time in advance of the output signal for initiating the preliminary operations. Once this advance time is chosen, a change of press speeds has no effect on it.

It will be readily appreciated that the paster anticipate circuitry could also be used to provide a signal a fixed period in advance of the second firing, or splicing operation, rather than in advance of the preliminary operations or first firing. The paster anticipate circuit could provide such an advanced signal with a minor modification. If the signal to the single shot 89 of the anticipate circuit is taken from the pulse shaper and reset circuit 55 of the pilot circuit instead of from the output of the pulse stretcher circuit 58, the desired result would be achieved.

The desired length of the fixed period TLOAD can be changed in two ways: (1) by adjustment of the frequency f_o of the fixed frequency oscillator 80 and (2) by adjustment of the count detected by the detector 110 of the anticipate circuit. Such an adjustment is facilitated by the variable resistor 142 of the oscillator 80 (FIG. 4a) and the interchangeable terminals 110a-110h of the count detector 110 as shown in FIG. 4e.

I claim as my invention:

1. In a digital control system for timing the splicing of the web from a new roll to a running web drawn from an expiring roll in which system preliminary operations are to be performed to make ready the new roll for splicing, the combination comprising

first pulse generating means operatively associated with the expiring roll for producing a reference pulse during a portion of each revolution thereof,
 second pulse generating means associated with the running web for producing timing pulses at a rate proportional to the speed of the running web,
 a first counter selectively coupled to said second pulse generating means and rendered operative at the trailing edge of the reference pulse for counting the timing pulses and producing a first control pulse when a preset number of timing pulses have been counted,
 means responsive to the first control pulse for generating a second control pulse of a fixed time duration,
 a source of auxiliary pulses at a constant frequency,
 a second counter selectively coupled to receive said timing pulses and said auxiliary pulses for producing a third control pulse when a preset number has been counted, and
 counter control means including a bistable circuit having a first stable state initiated by the trailing edge of said second control pulse during which counting by said second counter takes place and a second stable state initiated by said third control pulse during which said second counter is reset to a zero count,
 first coincidence sensing means coupled to said bistable circuit and said first pulse generating means for producing a first output signal in response to said first stable state and said reference pulse timely overlapping, said first output signal always occurring a fixed time interval in advance of a second output signal irrespective of the speed of the web, and
 second coincidence sensing means responsive to portions of the second control pulse and the reference pulse timely overlapping to generate said second output signal to initiate said preliminary operations.

2. A method for generating an electrical output pulse to indicate that a fixed period of time remains before the occurrence of preliminary operations to make ready for splicing in a system for timing the splicing of the web from a new roll to a running web drawn from an expiring roll, said method comprising the steps of
 generating a reference pulse during a portion of each revolution of the expiring roll;
 generating an enabling pulse at the trailing edge of each of said reference pulses;
 generating a train of timing pulses at a frequency which is proportional to the speed of the running web;
 counting said timing pulses, beginning at the occurrence of said enabling pulse and continuing until a first predetermined count has been achieved;
 generating a first control pulse upon achievement of said predetermined count;
 generating a second control pulse having a constant width upon the occurrence of said first control pulse;

generating a series of auxiliary pulses at a constant frequency;

counting said auxiliary pulses and said timing pulses immediately following said second control pulse and in response to the application of said second control pulse and continuing until a second predetermined count has been achieved;

detecting the time coincidence between a first reference pulse and said second predetermined count and generating a first output signal in response to said coincidence, said first output signal indicating that a fixed period of time remains before said preliminary operations; and

generating a second output signal to initiate preliminary operations upon the occurrence of time coincidence between said second control pulse and one of said reference pulses succeeding said first reference pulse.

3. An apparatus for indicating that a fixed period of time remains before the beginning of a splice control signal, the combination comprising

means operatively associated with a running web taken from a rotating roll for producing timing pulses at a frequency (f_p) proportional to the linear speed of the running web,

means operatively associated with said web rotating roll and producing a reference pulse in each revolution of said rotating roll,

an auxiliary pulse generator producing pulses at a fixed frequency (f_o),

pulse counter means coupled to receive and count said timing pulses and said fixed frequency pulses during a prescribed portion of each revolution of the expiring roll and to produce an output pulse upon achieving a predetermined count (N),

means associated with the running web for producing a count initiating pulse during each revolution of the expiring roll,

means connected to receive said count initiating pulse and said counter output pulse and for generating in response thereto a control pulse whose width (PW) varies according to the relationship $PW = N/(f_p + f_o)$, and

means sensing the coincidence of said control pulse and said reference pulse and producing an anticipate signal which indicates that said fixed period of time remains before the beginning of the splice control signal.

4. In a control system for a printing press whose linear printing velocity may be varied, for initiating splicing of a web on a new roll to a web running from a rotated expiring roll in response to a splice control signal originated at a predetermined expiring roll diameter, and for initiating preliminary make-ready of the web on the new roll in response to a make-ready control signal originated at a time in advance of said splice control signal which is varied as a function of printing press web velocity, means developing an anticipate control signal originated at a time in advance of said make-ready control signal which is of constant duration irrespective of printing press web velocity and comprising, in combination,

first pulse generating means producing a reference pulse during a portion of each revolution of said expiring roll,

second pulse generating means activated in each period of revolution of the expiring roll at a constant

time relative to said reference pulse and producing a first enabling pulse whose time position following said reference pulse approaches a succeeding reference pulse with diminishing expiring roll diameter and varies as a function of printing press web velocity, 5
 coincidence circuit means originating said splice control signal when a succeeding one of said reference pulses and said first enabling pulse coincide in time, 10
 third pulse generating means activated in each period of revolution of the expiring roll at a constant time following said first enabling pulse and producing a second enabling pulse whose time position with respect to said first enabling pulse is constant irrespective of printing press web velocity, 15
 coincidence circuit means originating said make-ready control signal when said succeeding one of said reference pulses and said second enabling pulse coincide in time, 20
 fourth pulse generating means activated in each period of revolution of the expiring roll at a constant time relative to said second enabling pulse and producing a third enabling pulse whose time position with respect to said second enabling pulse varies as an inverse function of printing press web velocity; and 25
 coincidence circuit means originating said anticipate

control signal when said succeeding one of said reference pulses and said third enabling pulse coincide in time, said anticipate control signal existing a constant time in advance of said splice control signal irrespective of printing press web velocity.

5. The invention defined by claim 4 wherein said second pulse generating means further comprises an adjustment means, said second pulse generator adjustment means being adjustable to vary the time position of said first enabling pulse with respect to said succeeding reference pulse for a predetermined expiring roll diameter.

6. The invention defined by claim 4 wherein said fourth pulse generating means further comprises an adjustment means, said fourth pulse generator adjustment means being adjustable to produce a third enabling pulse whose time position with respect to said second enabling pulse varies as a non-linear, hyperbola-like inverse function of printing press web velocity.

7. The invention defined by claim 4 wherein said fourth pulse generating means further comprises an adjustment means, said fourth pulse generator adjustment means being adjustable to vary the time position of said third enabling pulse with respect to said second enabling pulse to thereby vary the constant time of said anticipate control signal in advance of said make-ready control signal.

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