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 [21] Appl. No. **718,618**
 [22] Filed **Apr. 3, 1968**
 [45] Patented **Mar. 2, 1971**
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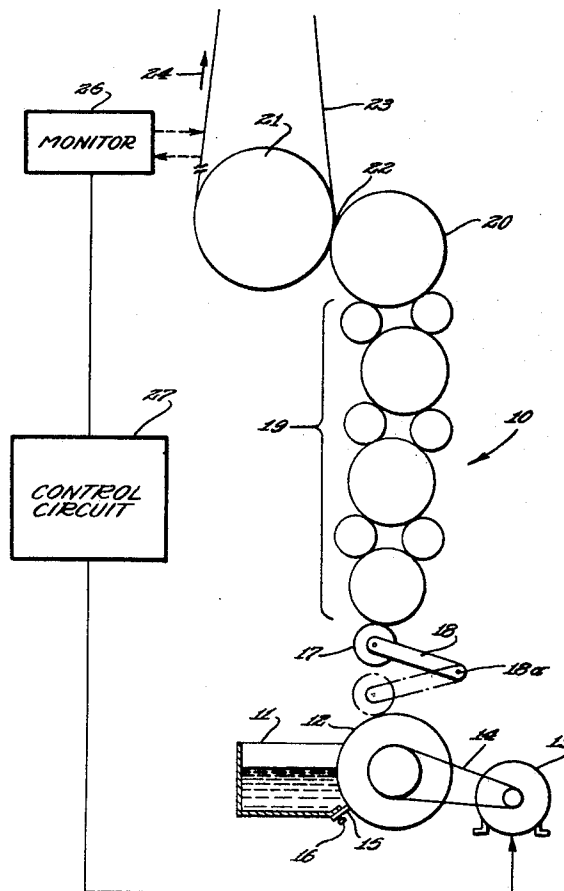
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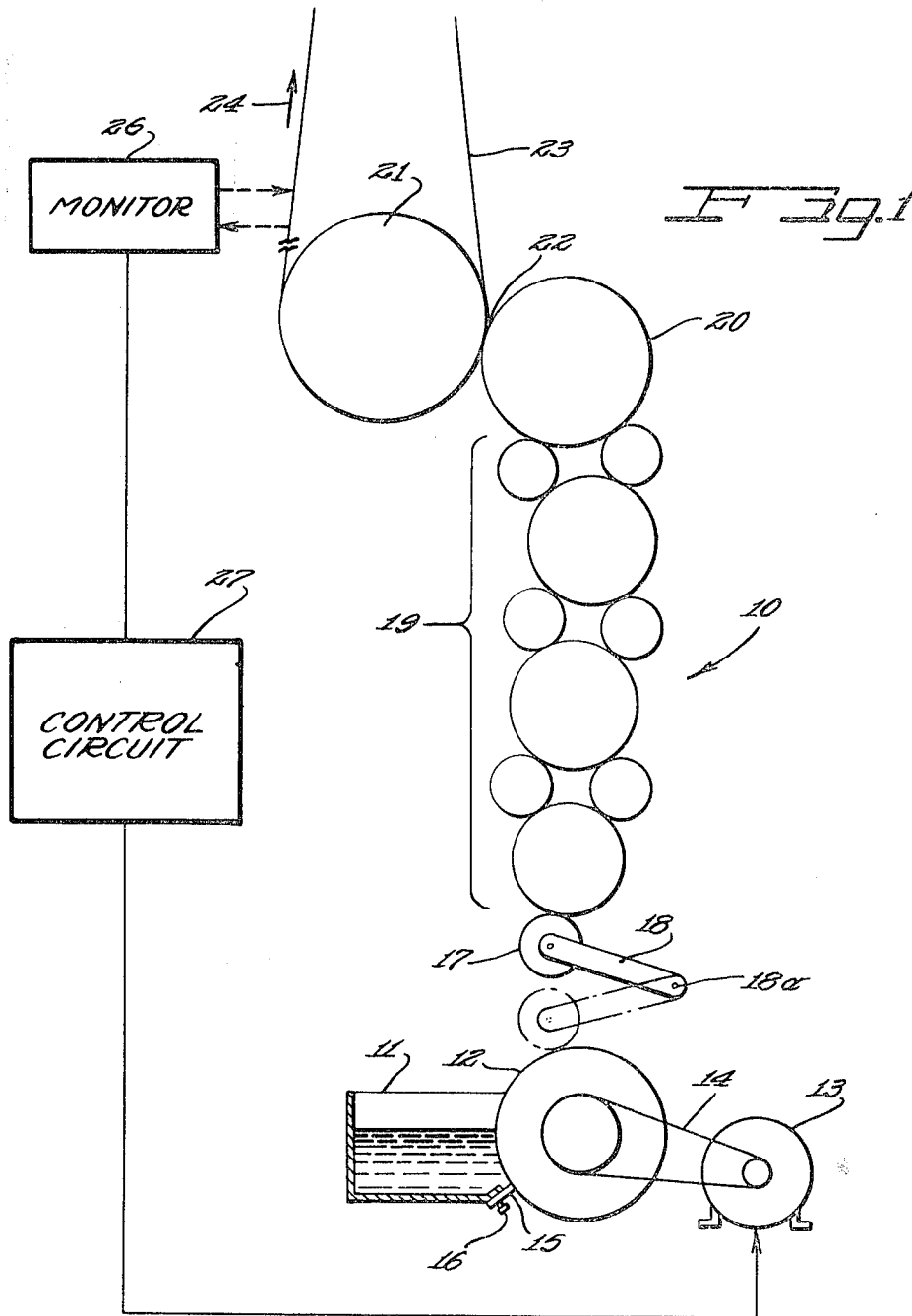
[54] **SYSTEM FOR MONITORING AND CONTROLLING
 THE COLOR DENSITY OF INK DURING PRINTING**
 12 Claims, 6 Drawing Figs.

[52] U.S. Cl. **250/226,**
 101/202, 101/350, 101/426, 250/219
 [51] Int. Cl. **G01n 21/26,**
 B41f 31/12
 [50] Field of Search. 250/226,
 219 (T); 101/142, 148, 202, 350, 426

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ABSTRACT: A system for monitoring and controlling the color density of ink applied to a surface of a moving web. A fountain roller receives ink from an ink supply and applies the ink to a printing cylinder which, in turn, applies the ink to the web surface. A sensing device senses the color density of the ink on the web surface and generates a control signal. The control signal is compared with a reference signal to develop an error signal. A storage circuit receives the error signal and, a sampling circuit is connected to the storage circuit to generate a control voltage which controls the amount of ink applied to the printing cylinder.

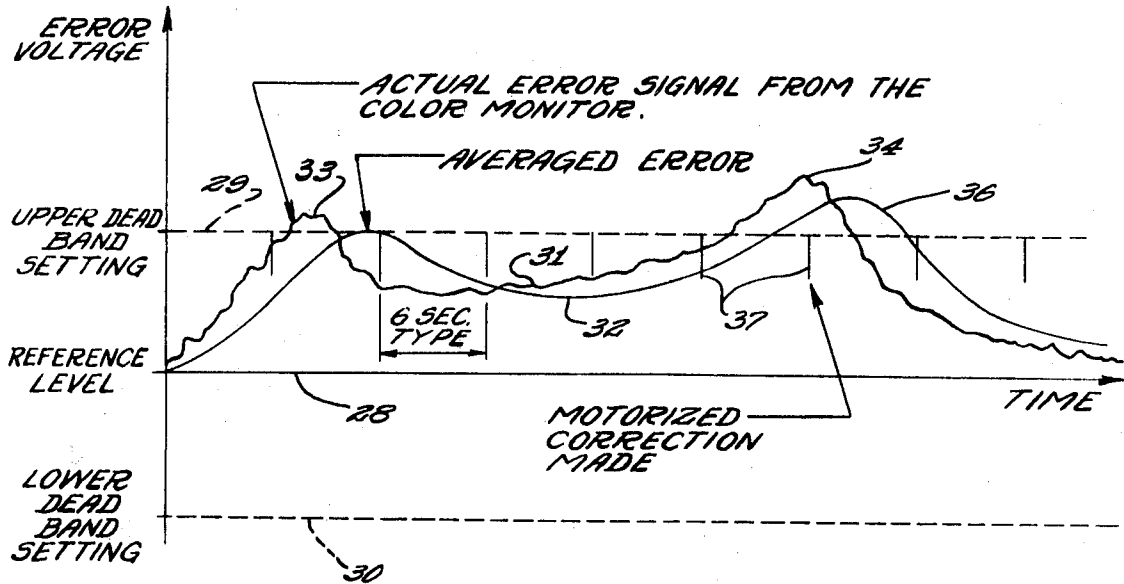




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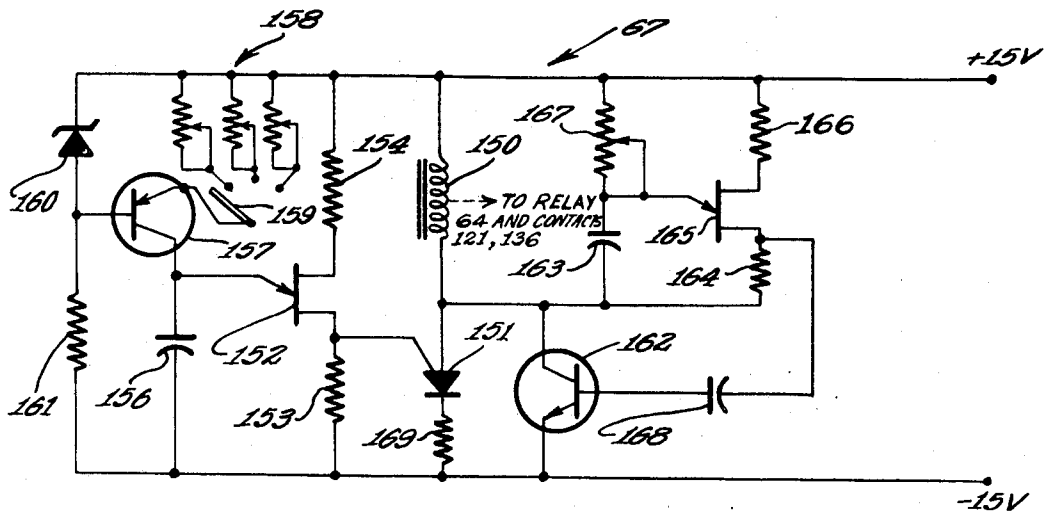
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Fig. 6



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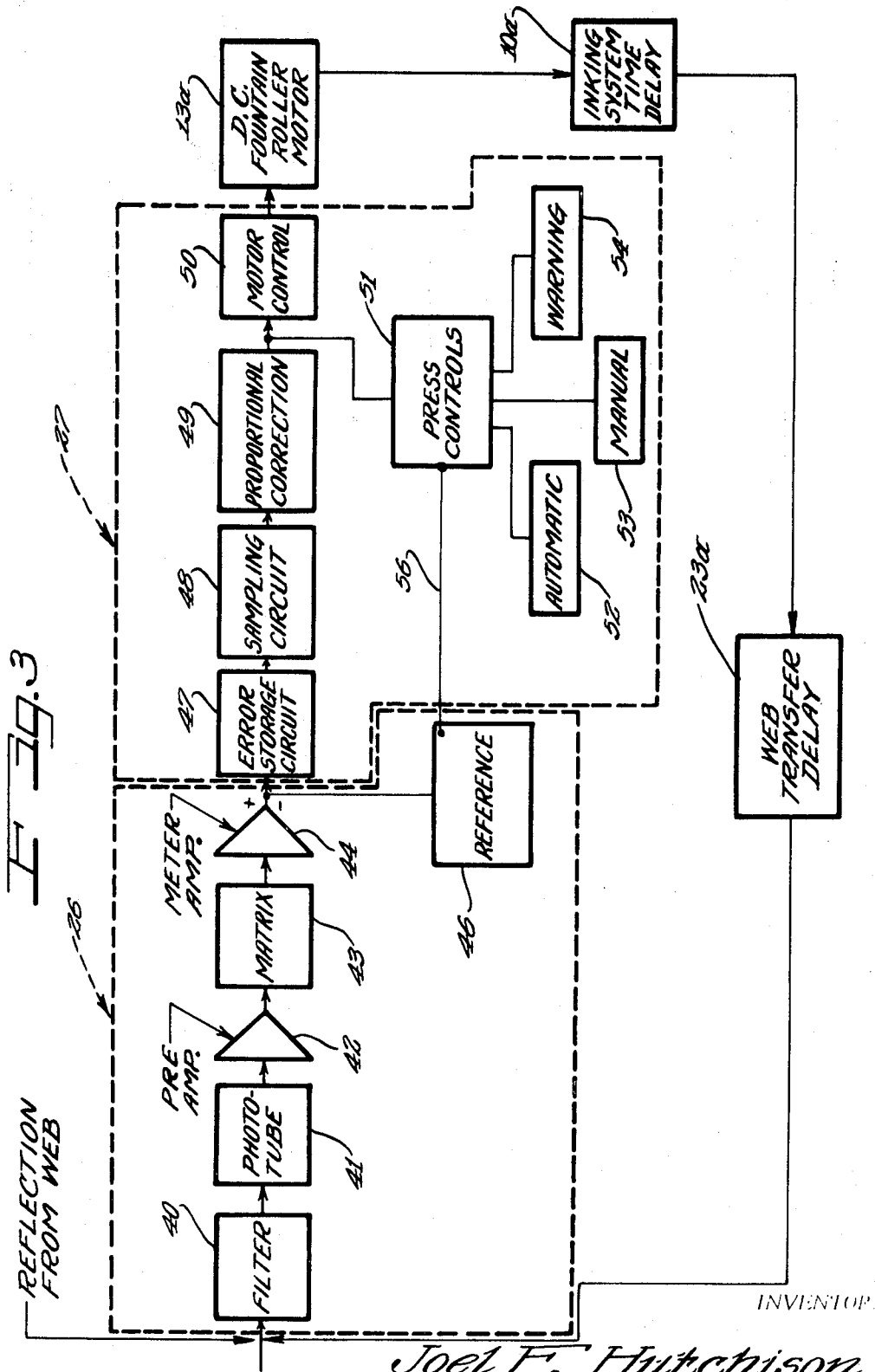
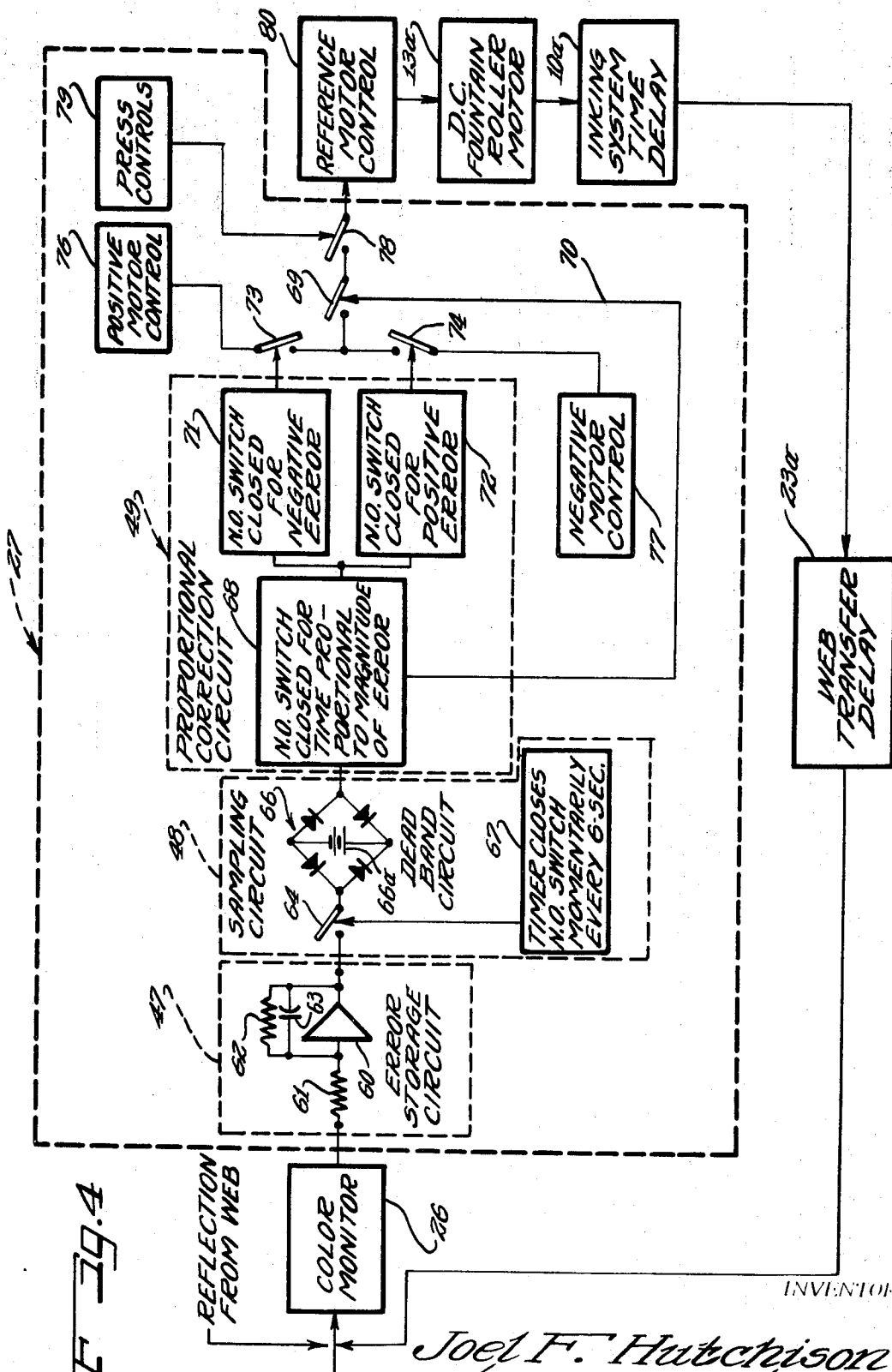


FIG. 3

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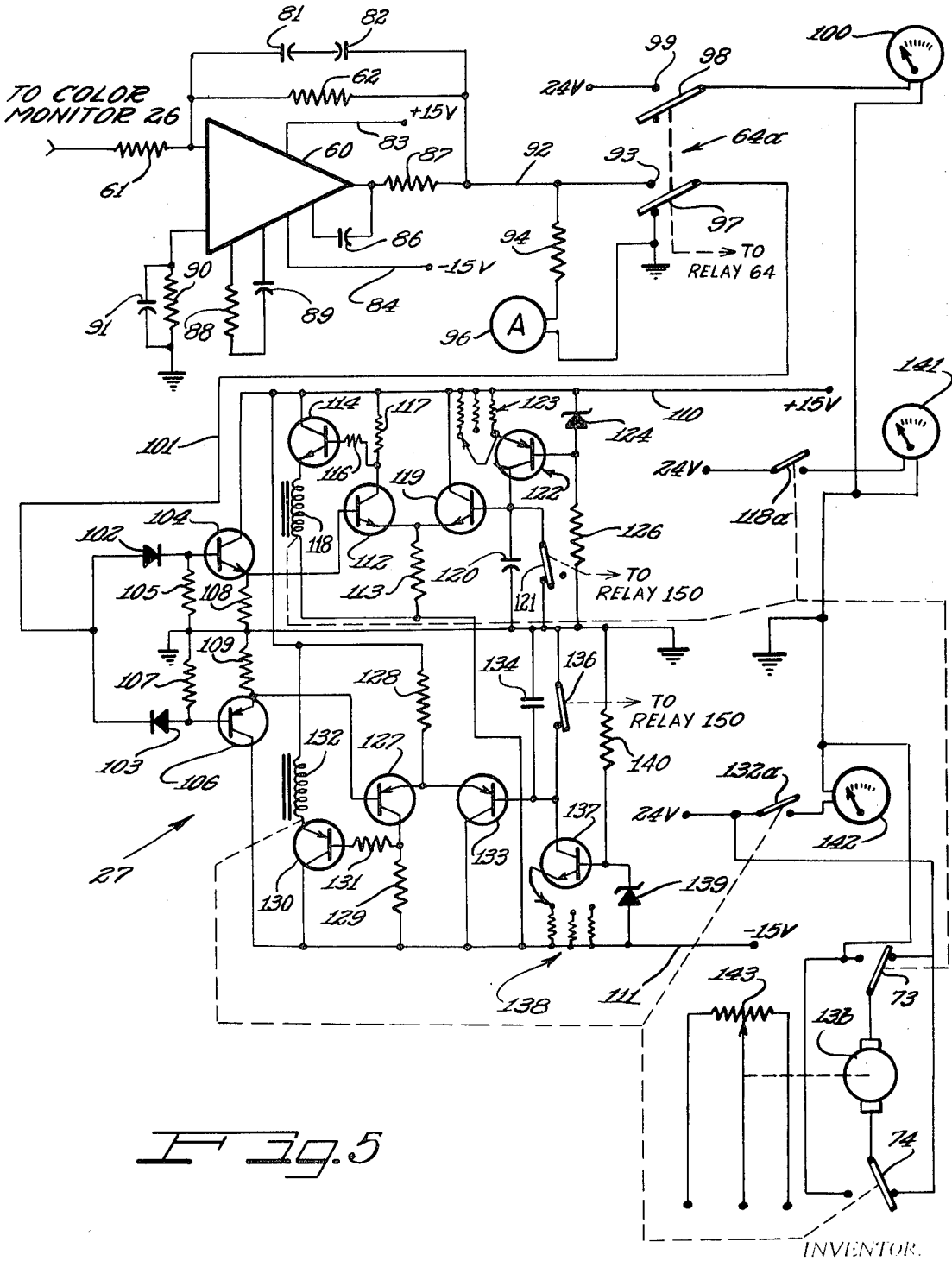


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SYSTEM FOR MONITORING AND CONTROLLING THE COLOR DENSITY OF INK DURING PRINTING

BACKGROUND OF THE INVENTION

This invention relates to a control system for the automatic monitoring and controlling of the color density of inks applied to the surface of a web. Specifically, this invention relates to a circuit means for storing signal information indicative of a color density, and periodically sampling the stored signal to generate a delayed control signal to maintain the color density on the web within predetermined minimum and maximum limits.

DESCRIPTION OF THE PRIOR ART

Heretofore, systems for monitoring the color density of ink applied to a moving web have included photosensitive devices for generating observable information. The observable information is then interpreted by an operator who makes the necessary adjustments to the printing machine. The time delay between the actual time of sensing the deviation of color density and the time when the operator effects the appropriate change is relatively long. This long time delay may cause a large quantity of unusable printed material to be processed before the correction affects the finished product. Furthermore, machine corrections performed by the operator are somewhat delayed from the time the operator makes the correction and the time the correction is sensed by the photoelectric monitor. This time delay will tend to cause the operator to overadjust the machine controls. Therefore, color density monitoring systems of the prior art are inefficient and inherently cause a substantial amount of waste.

SUMMARY OF THE INVENTION

One of the primary objects of the present invention is to provide a system for monitoring and automatically controlling the color density of ink applied to a moving web.

Another object of the present invention is to provide a system for monitoring the color density of ink applied to a moving web such that manual operation of the system is substantially eliminated.

Another object of the present invention is to provide a color density control system which will reduce the waste of automatic printing devices.

Still another object of the present invention is to provide a control system for monitoring and controlling the color density of ink applied to the surface of a web wherein the time between the sensing of the color density and the controlling of the color density is within a few seconds.

Still another object of the present invention is to provide a system for continuously monitoring and automatically controlling the color density of ink applied to the surface of a moving web.

Briefly, the principle of the color density control system of the present invention is to utilize the color density readings from a photoelectric monitoring device, and using these readings to control a servosystem to compensate for unwanted changes in the color density. This is accomplished by varying the fountain roller speed of a printing press. To achieve this end, the control system of the present invention compares the actual sensed color density with the speed of the particular fountain roller associated with that color. This is accomplished for all press speeds and color density levels.

Another method is to establish the level of the output power to the fountain roller motor which will provide correction for the incremental changes in the color density reading being detected by the color monitor.

The control system of the present invention is based upon the empirical data obtained by comparing the color density with fountain roller motor speeds for individual colors. It has been found that the color density is substantially linear with respect to fountain roller motor speed. That is, color monitor

variations versus fountain roller motor speed are substantially linear for such colors as blue, red and black. On the other hand, variations in yellow density due to variations in yellow fountain roller motor speeds are as small as the simultaneous changes in other color density readings, thus, providing substantially a nonlinear relation between the color monitor and the yellow fountain roller motor speed. The linearity of the color monitor versus fountain roller speed for colors blue, red and black greatly facilitate the operation of the color monitor and control system of the present invention. However, the nonlinearity of, for example, yellow can be compensated for by using a nonlinear control system.

A major factor to be considered in the design of the control system of the present invention is the inherent time delay between the time when the fountain roller motor changes its speed and the time when the affect of this motor change is sensed by the color density monitor. This delay is composed of two principal factors: Firstly, the time required to transport the additional ink from the initial inking roller to the printing cylinder and, secondly, the time required to transport the web from the printing nip to the color monitor station. While both of these periods will vary with the press speed, it is assumed that in normal operation the first time delay is approximately 1 second and the second time delay is in the order of 2½ seconds. Although the web transport delay could be somewhat reduced by moving the color scanning device closer to the printing nip, the color monitor would not indicate the true color density because the ink would still be wet and would reflect differently from dry ink. Additionally, it would be more desirable to scan the ink at approximately the same degree of surface dryness and oxidation as it would be when it leaves the press so as to insure a proper color fidelity.

The time delay in the inking system of a printing press is quite different from the time delay of the web transport from the printing nip to the color monitor. When a change in ink density is printed on the web, the same change will be sensed at the color monitor approximately 2½ seconds later. However, an abrupt change in fountain roller motor speed will result in a less abrupt change in ink density on the paper which occurs approximately 1 second later. In other words, the inking system between the fountain roller and the printing cylinder acts as a filter to prevent abrupt changes from occurring as the ink is applied to the web.

Accordingly, other objects, features and advantages will be more fully realized and understood from the following detailed description when taken in conjunction with the accompanying drawings wherein like reference numerals throughout the various views of the drawings are intended to designate the similar elements of our components.

A BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of an inking system which is controlled by the color monitor and a control system of the present invention;

FIG. 2 is a graphical representation of the actual error signal sensed by the color monitor and the average error signal developed by the color monitor;

FIG. 3 is a schematic block diagram illustrating one circuit arrangement of a monitor and control system of the present invention;

FIG. 4 is a schematic representation of the error and sampling circuitry of FIG. 3;

FIG. 5 is a detailed schematic diagram illustrating the sense and correction circuit of FIG. 4; and

FIG. 6 is a detailed schematic diagram of the sampling circuit of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a schematic representation of a printing apparatus using the monitor and control circuit constructed in accordance with the principles of this invention. The printing apparatus is designated generally by reference numeral 10. As-

sociated with the printing apparatus is an ink supply 11, which applies a thin coat of ink on the surface of a fountain roller 12. The fountain roller 12 is rotatably driven by a variable speed motor 13 which is coupled to the fountain roller 12 by a pulley or chain 14. The ink supply 11 includes a doctor blade 15 which is positioned very close to the surface of the fountain roller 12 and extends substantially the axial length of the ink supply 11. Adjusting means of 16 are associated with the doctor blade 15 to provide adjustment of the spacing between the edge of the doctor blade and the surface of the fountain roller. This adjustment controls the amount of ink which is applied to the surface of the fountain roller.

A doctor roller 17 is rotatably secured to a pivot arm 18 which pivots about a point 18a. The doctor roller oscillates up and down, as seen in the drawings, to pick up ink from the fountain roller 12 and apply the ink to the first of a series of idler transfer wheels which are indicated generally by reference numeral 19.

The ink from the idler transfer wheel 19 is applied to the surface of a printing cylinder 20. The surface of the printing cylinder 20 may be formed by a printing plate of the desired configuration. An impression cylinder 21 is positioned adjacent the printing cylinder 20 to form a nip region 22 between these two cylinders. A continuous moving web 23 is wrapped about a portion of the impression cylinder 21 and passes through the nip region 22 to receive the printed image thereon from the printing cylinder 20. The web 23 moves in a direction indicated by arrowed line 24.

The printed image on the web 23 is monitored or scanned by a monitoring device 26 which is positioned adjacent the web on the side thereof containing the printed image. The monitor 26 is of the reflective type directing a beam of light toward the printed surface and receiving a reflected beam of light from the printed surface. The monitor 26 produces control signal information indicative of the color density of the printed image on the web 23. The control signal information is applied to a control circuit 27 which, in turn, develops an error signal by comparing the control signal information of monitor 26 with a reference voltage. This error signal is used to control the speed of rotation of drive motor 13.

During the operation of the inking system of FIG. 1 the fountain roller 12 is continuously driven by the drive motor 13. The fountain roller turns in the ink supply 11 and, the thickness of the ink on the surface of the fountain roller is determined by the setting of the doctor blade 15. Alternately, the doctor roller 17 oscillates up and down to intermittently touch the fountain roller 12 and pick up an amount of ink to be applied to the idler transfer rollers 19. The ink is then transferred across the surface of the series of idler rollers and finally applied to the surface of the printing cylinder 20. The ink on the surface of the printing surface 20 is impressed on the surface of the moving web 23. The amount of ink picked up by the doctor roller while in contact with the fountain roller is dependent on two factors: Firstly, the thickness of the ink determined by the doctor blade 15; and, secondly, the amount of surface of the fountain roller touching the doctor roller. The amount of surface is directly dependent upon the speed of the fountain roller which, in turn, is dependent on the speed of the drive motor 13. Because the idler transfer rollers 19 are turning at approximately press speed, the time delay for the ink to reach the nip region 22 from the fountain roller 12 is approximately 1 second. In addition to the time delay of ink transfer caused by the ink delivery system, the inking cylinders smooth out or filter any abrupt changes in the amount of ink picked up by the doctor roller so that a sudden increase of ink on the fountain roller results in a gradual increase in the ink density applied to the web 23.

As the time delay increases, the response of the control system 27 and motor 13 become more sluggish. Even when other time parameters of the control system are very small, the sum of the ink system and web transfer delays is sufficient to cause instability with any reasonable amount of open-loop gain. This instability results primarily from two causes. First, a

reasonably high gain system with attempt to correct for relatively high frequency errors which are not characteristic of color density errors. Secondly, because of a web transfer delay, a continuously controlling system would not have immediate feed back, and, thus, would not immediately know how a previous correction had affected the color density.

It has been determined empirically that the phase shift of the web transfer delay is approximately 90° at 0.5 radians per second of the impression roller 21 when the impression roller has a diameter of 7 inches. Also, this phase shift continues to increase with increasing frequency. This effect will add an instability to the system because of the long time delay between initiation of a change in ink density and the actual detection of such change by the monitor 26.

In order to minimize the instability which occurs because of the long time delay within the web transfer system, an error sample system is used in the control system of the present invention. Additionally, the control system of the present invention incorporates an error storage time which allows the system to neglect high frequency errors. The error storage time, in effect, produces an average error over a short time base, for example, a few seconds. The sampling time period for this system will be the web transfer delay plus the error storage delay, the sum of which is approximately 6 seconds. Therefore, the control system of the present invention compensates for the time delays of the press and corrects for slow drifts in the color density associated with the color printing on the web 23.

The control of the color density versus fountain roller speed of a particular color also affects the color density of other associated colors applied to the web 23. This effect of one color on another is a cross coupling effect and is a property of the color monitor 26. Therefore, the control system 27 is provided with means to compensate for this effect by establishing small dead bands which will prevent corrective action until a preestablished threshold has been exceeded. This threshold will be selected to be above the cross coupling level.

The color monitor 26 includes a plurality of photoelectric scanners for monitoring distinct longitudinal areas or ribbons of the web 23. The fountain roller 12 provides changes in ink across the entire width of the web, and the error signal developed by the control circuit 27 will be the average of the readings of the several scanners positioned transversely to the web 23.

The color monitor and control system of the present invention will continuously monitor the color density of ink applied to the web 23, but will correct deviations or errors only at periodic time intervals. For example, at the beginning of each printing run, a favorable copy is used to set the reference motor speed for the fountain roller motor 13. This reference setting can be adjusted manually at any time during the printing operation. The system stores the error signal from the monitor 26, and averages the error over a small time base. When the average error exceeds the dead band and is sampled simultaneously, motorized correction will be initiated to change the speed of the motor 13. This system allows the actual error from the color monitor 26 to exceed the dead band or level for a few seconds before motorized correction is made. Therefore, if the error again drops below the threshold of the dead band, no correction is made.

The unique operation of the monitoring control system of the present invention will be better understood from the graphical representation shown in the FIG. 2. The reference level is indicated by a reference line 28 which extends horizontally and represents a time base. The upper dead band setting is represented by a dashed line 29, while the lower dead band setting is represented by a dashed line 30. The actual error from the color monitor 26 is represented by the curved line 31, and, the average error is represented by the curved line 32. When the monitor 26 senses color density deviations greater than the upper dead band setting, the curved line 31 will have peaks which extend beyond the upper dead band setting, such as the peaks 33 and 34. However, due

to the averaging of the actual error signal peak 33 may be reduced below the upper dead band setting of the control circuit 27 such that no corrective action will be taken to change the speed of motor 13. On the other hand, the peak 34 of curved line 31, when filtered, remains greater than the dead band setting 29.

During the monitoring of the color density of the ink applied to the web 23 a switching circuit continuously operates to sample the average error signal 32 at predetermined spaced intervals. These intervals, may be in the order of 6 seconds apart. The switching pulses are shown as the downward extending spikes 37 along the upper dead band setting 29, FIG. 2. The control circuit of the present invention provides an AND circuit such that the average error setting must exceed the dead band setting at a time point when the switching or sampling is being made. That is, the peak 36 of the average error and one of the negative switching spikes 37 must coincide. The motor speed is changed proportional to the magnitude of the average error above the reference level 28. This will cause the speed of motor 13 to vary over a range of, for example, 80 r.p.m. which is approximately 13 percent of the proportional band. Thus, the error within the desired dead band setting of a particular color density is held by the system by using proportional correction.

As seen in FIG. 3 is a circuit block diagram illustrating the various components of the monitor 26 and control circuit 27. The drive motor 13 is designated by reference numeral 13a while the inking system time delay is designated by reference numeral 10a. The web transfer time delay is designated by reference numeral 23a.

The monitor 26 includes a color filter device 40 which receives light reflection from the printed surface of the web 23. The filter 40 prevents unwanted signals representing different colors from entering a phototube 41. The output of the phototube 41 is applied to a preamplifier 42 wherein the control signal is amplified and applied to a matrix circuit 43. The matrix circuit 43 includes a plurality of inputs from the aforementioned plurality of photoelectric scanners disposed transversely of the web. In FIG. 3, however, only one such photoelectric scanner is illustrated in the form of elements 40, 41 and 42. The matrix circuit 43 is connected to a meter amplifier 44 which gives a visual indication of the control signal developed from the reflected signal of the web 23. The meter amplifier 44 therefore responds to color density signals from across the entire web. The output of the meter amplifier 44 is combined with a reference voltage from a reference circuit 46. This combined signal produces the error signal used to control the operation of the printing system.

The error signal is delivered to the control circuit 27 and applied to an error storage circuit 47. The error signal stored in the storage circuit 47 is periodically sampled by the use of an electronic sampling circuit 48. The sampling circuit samples the error signal at time intervals corresponding to the negative spikes 37, FIG. 2. The sampled error signals are delivered to a proportional correction circuit 49 and, therefrom, to a motor control circuit 50. Also connected to the input motor control circuit 50 is a press control circuit 51 which includes an automatic control 52, a manual control 53, and a warning device 54. The press controls 51 are also connected to the reference circuit 46 via a line 56. This enables the operator to vary the reference voltage applied to the output of the metering amplifier 44 from the press control circuit 51.

The output of the motor control 50 controls the speed of rotation of the fountain roller motor 13a, and the feedback to the input of filter 40 is represented by the inking system time delay 10a and the web transfer time delay 23a. By proportioning the circuit parameters of the control circuit 27 to compensate for the mechanical time delay of the system, the control system of the present invention functions as a closed loop servosystem.

Seen in FIG. 4 is a more detailed showing of the control circuit 27 of FIG. 3. The output of the color monitor 26 is applied to the error storage circuit 47 which includes an ampli-

er 60. A series input resistor 61 is connected between the color monitor 26 and amplifier 60 to provide a high input impedance for the error storage circuit 47. The resistor 61 is preferably 10^6 ohms. A feedback resistor 62 is connected in parallel with the amplifier 60 and, the value of resistor 62 is approximately equal to the value of resistor 61. A capacitor 63 is connected in parallel with resistor 62 and has a capacitance value of 4 microfarads. Therefore, the RC time constant of the feedback circuit is 4 seconds.

The output of the error storage circuit is applied to the sampling circuit 48 through a switch 64 and therefrom to a dead band circuit 66. The dead band circuit 66 is shown as a diode bridge circuit having a voltage source connected between the center point of the two legs of the bridge network. The sampling switch 64 is controlled by an electronic relay circuit 67 which momentarily closes the switch 64 every 6 seconds.

The output of the sampling circuit is then delivered to an electronic relay circuit 68 of the proportional correction circuit 49. The electronic relay circuit 68 controls the actuation of a relay switch 69, which is part of the relay control circuit 68, as indicated by a connection line 70. Also connected to the relay control circuit 68 is a negative error control circuit 71 and a positive error control circuit 72. Error control circuit 71 controls the operation of a relay switch 73 and, the error control circuit 72 controls the operation of a relay switch 74. Relay switch 73 is connected to a positive motor control source 76 and, relay switch 74 is connected to a negative motor control source 77. The motor control potential of the proper polarity is applied through the relay switch 69 and through a press control switch 78 which is operated by a press control circuit 79. The output of the control circuit 27 is then applied to a reference motor control 80 and therefrom to the fountain roller motor 13a to control the speed of operation of the fountain roller 12, of FIG. 1.

In operation, the error storage circuit 47 supplies an error storage time to the system which, in effect, averages the error during a 4 second interval, which is the time constant of the feedback circuit comprising resistor 62 and capacitor 63. By using an error storage circuit in accordance with this invention the attenuation or losses within the storage circuit are minimized. For example, the gain of the error storage circuit 47 is unity. This is accomplished by providing the operational amplifier 60 with an input impedance substantially equaling the feedback impedance. The operational amplifier has an input impedance of 10^{10} ohms and a gain of 100 db. which allows the error storage circuit to have a high input impedance. A high input impedance into the error storage circuit is desired in order to reduce the effects of the output circuit of the color monitor 26.

In the sampling circuit 48, the electronic relay circuit 67 acts as a timer, and closes the normally open switch 64 momentarily to allow the error signal from the storage circuit 47 to reach the dead band circuit 66. The dead band circuit is a diode bridge network with an adjustable DC bias source 66a which determines the width of the dead band. If an error signal exceeds the dead band, the signal enters the proportional correction circuit 49 thereby causing switch 69 and either one of the switches 73 or 74 to close to apply the proper polarity potential to the fountain roller motor 13a. That is, a negative error will close the switch 73 to apply a positive correction to the system and, a positive error will close switch 74 to apply a negative correction to the system. According to the present invention, switch 69 is closed for a period of time proportional to the magnitude of the error sensed by the electronic relay circuit 68. The operation of the switch 69 in conjunction with the electronic relay circuit 68 provides a proportional control system. When the printing press is operating in a normal fashion, the press control switch 78 is closed and the operation of switches 73 and 74 will apply the proper corrective voltage to the fountain roller motor 13a.

FIG. 5 shows a detailed schematic circuit of the control circuit 27 of FIG. 4. The input signal from the color monitor 26 is applied to the proportional amplifier 60, as mentioned here

and above. The capacitor 63, FIG. 4, is replaced by a pair of series connected capacitors 81 and 82. A positive 15 volt source is connected to the proportional amplifier 60 by way of line 83 and a negative 15 volt source connected to the proportional amplifier through a line 84. The output of the proportional amplifier 60 includes a capacitor 86 and a series connected resistor 87. A resistor 88 and a capacitor 89 are connected to the proportional amplifier 60 to dimension the amplifier in accordance with the requirements of the present invention. Also connected to the proportional amplifier 60 is a resistor 90 and a capacitor 91. The output of the proportional amplifier 60 is applied to a line 92 which is connected to a normally open contact of the sampling switch 64a. The sampling switch 64a, seen in FIG. 5, comprises a plurality of contactors. Also connected to the output line 92 is a meter circuit comprising a resistor 94 and a meter 96. The meter 96 is preferably a center position meter indicating negative and positive current flow.

A movable contactor 97 is intermittently connected to the contactor 93 to transfer the error storage signal to the sampling circuit, as mentioned here and above. A second movable contactor 98 intermittently engages a stationary contact 99 to apply a 24 volt potential to a sampling indicator 100.

The error storage signal is delivered through a line 101 to a pair of diodes 102 and 103. The diode 102 has the cathode thereof connected to the base electrode of a transistor 104. Also connected to the base electrode of transistor 104 is one end of a resistor 105. The other end of resistor 105 is connected to ground potential. The anode of diode 103 is connected to the base electrode of a transistor 106 and to one end of a resistor 107. The emitter electrodes of each of the transistors 104 and 106 are connected to a ground potential through resistors 108 and 109 respectively. The collector electrode of transistor 104 is connected to a +15 volt source through a line 110 and the collector electrode of transistor 106 is connected to a -15 volt source through a line 111.

The sampled error signal developed by the transistor 104 is applied to the base electrode of a transistor 112 which has the emitter electrode thereof connected to the negative 15 volt source through a resistor 113. The output of a transistor 112 is applied to the base electrode of a transistor 114 through a resistor 116. Also connected to the collector electrode of transistor 112 is a resistor 117 which applies operating potential to the transistor 112. Connected in the series with transistor 114 is a relay coil 118. The relay coil 118 controls the actuation of a relay switch 118a and the relay switch 73 associated with the motor 13b.

Also connected to the emitter electrode of a transistor 112 is the emitter electrode of a transistor 119. The base electrode of transistor 119 is connected to ground potential through a capacitor 120 and a relay switch 121. Relay switch 121 is actuated simultaneously with relay switch 64a, and may be operated from the same relay coil. A transistor 122 has the collector electrode thereof connected to the base electrode of transistor 119 and, the emitter electrode thereof connected to the line 110 through a variable resistance network 123. The base electrode of transistor 122 is connected to the anode of a Zener diode 124 and to ground potential through a resistor 126. During the nonsampling portion of the control circuit, relay switch 121 is closed thereby forward biasing a transistor 119 which, in turn, maintains transistor 112 in the cutoff state. Therefore, control signals applied to the base of a transistor 112 will not effect the conduction of the transistor until relay switch 121 opens.

The output of transistor 106 is applied to the base electrode of a transistor 127 which has its emitter electrode connected to line 110 through a resistor 128. The collector electrode of transistor 127 is connected to line 111 through a resistor 129. The collector electrode of transistor 127 is also connected to the base electrode of a transistor 130 through a resistor 131. Transistor 130 is connected in series with a relay coil 132. Relay coil 132 controls the actuation of a relay switch 132a and the relay switch 74, associated with the motor 13b.

Connected to the emitter electrode of a transistor 127 is the emitter electrode of a transistor 133. The base electrode of transistor 133 is connected to ground potential through a capacitor 134 and a relay switch 136. Relay switch 136 operates simultaneously with relay switch 121 and sampling switch 64a. As mentioned here and above, relay switch 136 as well as relay switch 121 may be operated from the same relay coil as sampling switch 64a.

Also connected to the base electrode of transistor 133 is the collector electrode of a transistor 137. The emitter electrode of transistor 137 is connected to line 111 through an adjustable resistor network 138. The base electrode of transistor 137 is connected to a Zener diode 139 and to ground potential through a resistor 140.

Relay switch 118a applies the voltage to a correction indicator 141, while relay switch 132a applies voltage to a correction indicator 142. Indicators 100, 141 and 142 are located on an indicator panel which is observed by the press operator. Also, a potentiometer 143 may be controlled by the motor 13b to give an indication of the actual fountain roller speed.

The transistor 122 together with the adjustable resistor network 123 and Zener diode 124 provide the adjustable bias network to set the upper dead band of the control system. Similarly, transistor 137 together with adjustable resistance network 138 and Zener diode 139 form the adjustable bias circuit for the lower dead band setting. As mentioned hereinabove, transistors 112 and 127 remain nonconductive as long as switches 121 and 136 are closed. However, when switches 121 and 136 become open transistors 112 and 127 will remain nonconductive unless the input signal applied to these transistors exceeds a given level determined by the circuit parameter of the dead band circuits. Therefore, either relay coil 118 or relay coil 132 is energized, depending on the sense, positive or negative, of the error signal only when the switches 121 and 136 are open and when the error signal is of a predetermined magnitude.

FIG. 6 is a detailed schematic diagram of the electronic relay control circuit 67, FIG. 4. The relay control circuit 67 includes a relay coil 150 connected in series with a silicon controlled rectifier 151 which, when rendered conductive, energizes the relay coil 150. The silicon controlled rectifier 151 is rendered conductive by a unijunction transistor 152 which has a resistor 153 connected to one base electrode thereof and a resistor 154 connected to the other base electrode. A charging capacitor 156 has one end thereof connected to the emitter electrode of unijunction transistor 152 and the other end thereof connected to a negative 15 volt source. Connected in series with the charging capacitor 156 is a transistor 157 and an adjustable resistance network 158. A switch 159 provides means for selecting a desired one of the resistors of the resistor network 158 to be connected in series with transistor 157. Therefore, resistor network 158 together with transistor 157 determine the charge rate of the charging capacitor 156 which, in turn, determines the firing point of the unijunction transistor 152. Transistor 152 operates as a relaxation oscillator. The voltage applied to the charging circuit of capacitor 156 is maintained constant by a voltage regulator circuit comprising a Zener diode 160 and a resistor 161.

Connected in parallel with the silicon control rectifier 151 is a transistor 162. The collector electrode of transistor 162 is connected to one end of a capacitor 163 and a resistor 164. Resistor 164 is connected to one base electrode of unijunction transistor 165 and, a resistor 166 is connected to the other base electrode of a transistor 165. Connected to the emitter electrode of transistor 165 is the other end of the capacitor 163 and a potentiometer 167. Potentiometer 167 controls the charge rate of capacitor 163 which, in turn, controls the point at which the unijunction transistor 165 is rendered conductive. An output pulse developed by transistor 165 is applied to the base electrode of transistor 162 through a capacitor 168. Transistor 162 is rendered conductive for a short period of time thereby shunting the silicon controlled rectifier 151 to commutate the controlled rectifier to the nonconductive state.

To insure that there is sufficient voltage drop developed across the silicon controlled rectifier 151, a resistor 169 is connected in a series therewith.

The potentiometer 167 controls the time duration which relay coil 150 is energized. Relay coil 150 controls the actuation of the relay switch 64. FIG. 4, and the relay switches 64a, 121 and 136, FIG. 5.

Accordingly, the color density control system of the present invention provides means for continuously sampling a delayed error storage signal and comparing the sampled signal with dead band settings of predetermined magnitude to effect the control of a printing press. Although only the preferred embodiment of the present invention is set forth in great detail, it will be understood that variations and modifications may be affected without departing from the spirit and the scope of the novel concepts of this invention.

I claim:

1. An apparatus for controlling the color density of ink applied to a continuously moving web, comprising:
 - an inking device for applying ink to the surface of said web;
 - a color density monitor including a plurality of scanners directed across the web for scanning the ink on the web surface to generate signals indicative of the color density, including means for averaging said signals and means for comparing the average color density signal with a reference potential to derive an error signal;
 - an error signal delay circuit connected to said color monitor for receiving and delaying said error signal;
 - a dead band circuit having biasing means for setting an upper and a lower reference potential;
 - a sampling circuit connected between said error storage circuit and said dead band circuit for applying the stored error signal information to said dead band circuit at predetermined spaced intervals;
 - a proportional control circuit connected to said dead band circuit for receiving sampled error signals which exceed the upper and lower reference potentials of said dead band circuit; and
 - a voltage control circuit connected to said inking device and operated from said proportional control circuit to apply a corrective voltage to said inking device, said corrective voltage having a polarity corresponding to the sense of said average color density signal.
2. An apparatus for controlling the color density of ink applied to the surface of a continuously moving web according to claim 1 wherein said error delay circuit includes:
 - a proportional amplifier, a resistor connected in series with the input of said proportional amplifier, a feedback resistor connected between the input and output of said proportional amplifier, said feedback resistor having approximately the same value as said series connected resistor, a capacitor connected in parallel with said feedback resistor, whereby the RC time constant of said feedback resistor and capacitor is approximately 4 seconds.
3. An apparatus for controlling the color density of ink applied to the surface of a continuously moving web according to claim 1 wherein said sampling circuit includes:
 - a relay coil, a silicon controlled rectifier connected in series with said relay coil, an adjustable frequency oscillator connected to the gate electrode of said silicon controlled rectifier for rendering said silicon controlled rectifier conductive at predetermined spaced intervals;
 - a transistor connected in parallel with said silicon controlled rectifier; and
 - a time duration circuit responsive to the conduction of said silicon controlled rectifier for rendering said transistor conductive at a predetermined time after the conduction of said silicon controlled rectifier, thereby, causing the silicon controlled rectifier to become nonconductive.
4. An apparatus for controlling the color density of ink applied to the surface of a continuously moving web according to claim 3 wherein said adjustable frequency oscillator is a

unijunction transistor oscillator, and wherein said time duration of circuit includes a charging capacitor, a unijunction transistor having the emitter electrode thereof connected to one end of said capacitor and one base electrode thereof connected to the other end of said capacitor whereby, charging of said capacitor to a predetermined voltage will cause the unijunction transistor connected thereto to develop a pulse to render said transistor conductive.

5. Apparatus for controlling the color density of ink applied to a continuously moving web, comprising: controllable means for applying ink to a fountain roller; a printing cylinder; means for transferring the ink from said fountain roller to said printing cylinder; means for transferring the ink from said printing cylinder to the moving web; means for scanning the ink across the web to provide a signal indicative of average color density, means for comparing said color density signal with a reference signal to produce an error signal for deviations of said average color density signal from said reference signal; circuit means having an upper and a lower threshold defining therebetween a dead band and responsive to an error signal outside of the dead band to produce an ink control signal; and means for applying the ink control signal to said controllable ink applying means for controlling the operation thereof.

6. Apparatus according to claim 5 further comprising means connected between said comparing means and said circuit means for delaying the error signal.

7. Apparatus according to claim 6, further comprising sampling means interposed between said delaying means and said circuit means for periodically providing samples of the delayed error signal to said circuit means.

8. Apparatus according to claim 6 wherein said delaying means includes a proportional amplifier, a resistor connected in series with the input of said amplifier, a feedback resistor connected between the output and the input of said amplifier and having the same value as said series connected resistor, and a capacitor connected in parallel with said feedback resistor to provide a time constant of approximately 4 seconds.

9. Apparatus according to claim 5, wherein there is an inking system delay time for ink travel between said controllable ink applying means and said printing roller, and an ink transfer delay time for ink travel between said printing roller and said scanning means, and wherein said apparatus comprises error signal delay means for delaying the error signal for an interval to render the transfer delay time and the error signal delay time substantially equal to the inking system delay time.

10. Apparatus according to claim 9 comprising sampling means interposed between said delay means and said circuit means and operable to provide said circuit means with samples of the error signal periodically at intervals substantially equal to the inking system delay time.

11. A method of controlling the color density of ink applied to a continuously moving web, comprising:

- applying ink to a fountain roller;
- transferring the ink to the surface of a printing cylinder;
- transferring the ink from the printing cylinder to the surface of the moving web;
- electrically sensing across the web the density of the ink on the surface of the web and generating corresponding color density signals;
- combining the color density signals to provide an average color density signal;
- providing a reference potential between a pair of threshold levels;
- deriving an error signal as a deviation of the average color density signal from the reference potential;
- delaying the error signal; and
- adjusting the application of ink to the fountain roller in accordance with the magnitude and polarity of the delayed error signal which exceeds either threshold level.

12. A method according to claim 11, comprising the step of periodically sampling the delayed error signal for adjusting the application of ink to the fountain roller.