

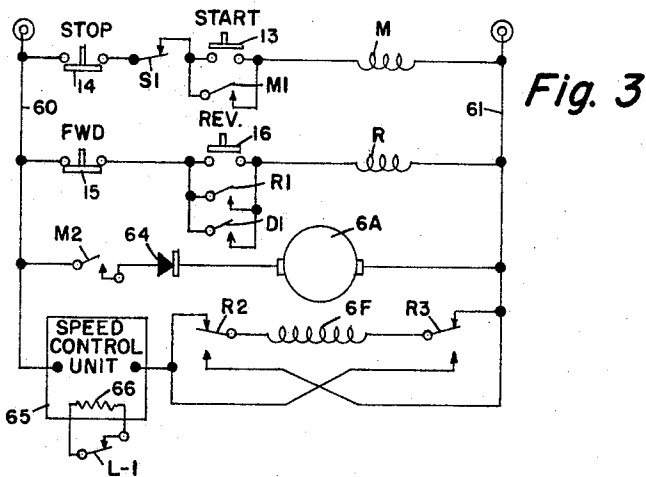
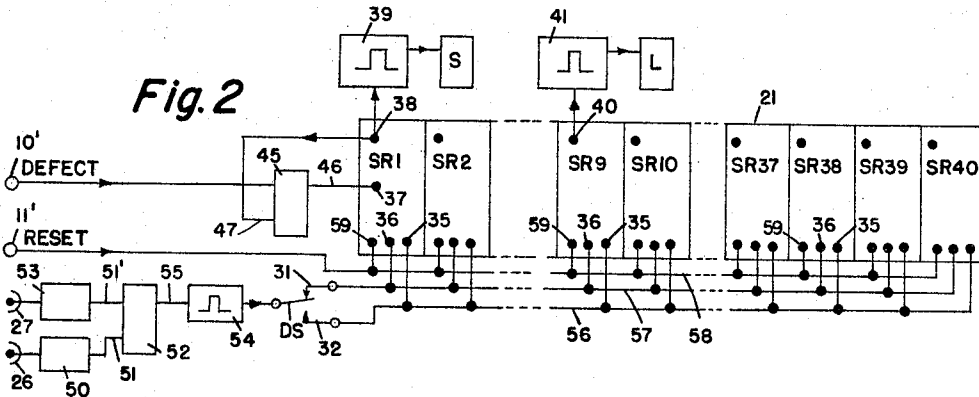
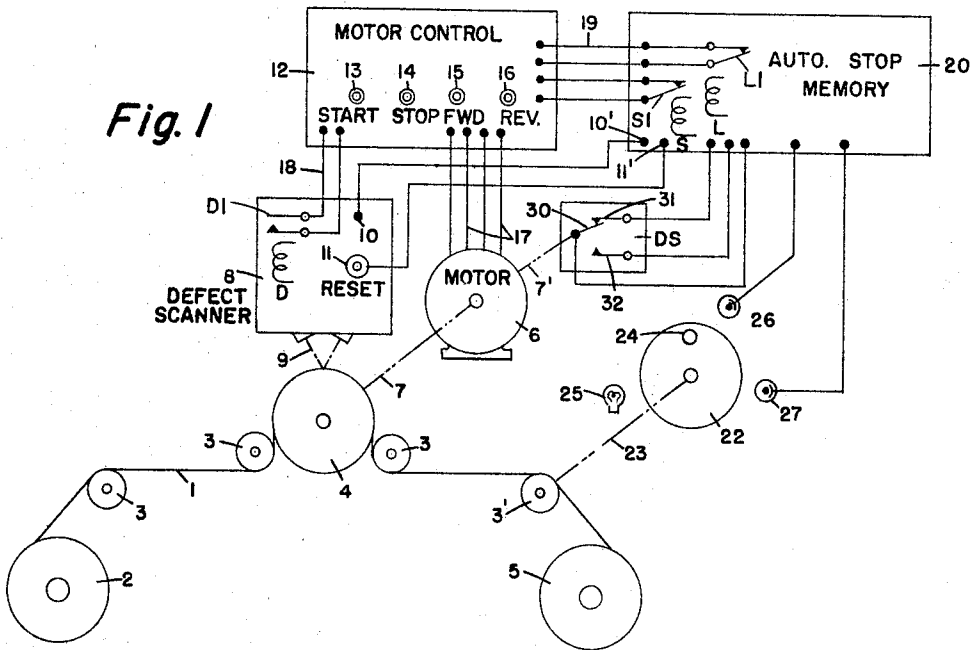
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H. J. EMERSON

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WEB INSPECTION SYSTEM

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HOWARD J. EMERSON
INVENTOR.

BY *R. Frank Smith*
Robert F. Crocker
ATTORNEYS

1

3,270,930

WEB INSPECTION SYSTEM

Howard J. Emerson, Rochester, N.Y., assignor to Eastman Kodak Company, Rochester, N.Y., a corporation of New Jersey

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This invention relates to a web inspection system and particularly to such a system which is especially well adapted for use in conjunction with the inspection of a web of photographic material.

In the manufacture of photographic film and other web materials, it is desirable that such web be completely free from defects which might make it unsuitable for its intended purpose. It is, moreover, desirable that such inspection be carried out at relatively high speeds and it has therefore become the practice to utilize automatic defect scanning mechanisms which electro-optically or in some other fashion, scan the web as it moves past an inspection station and produces a control signal whenever a defect in the web is sensed thereby. This defect signal may, of course, be utilized in any manner desired. For example, it may be used to sound an alarm, actuate an indicating device, actuate a web marker so as to produce a distinctive mark on the web in the vicinity of the flaw, or for any other desired purpose.

However it has been found that many apparent flaws sensed by such apparatus may not be actual flaws of such character as to render the material unsuitable for its intended purpose. For example, quite frequently it is found that a loose speck of dust on the surface of a web of photographic material will, with such scanning units, produce a defect signal when, in fact, the web itself is in perfect condition at that point. Of course, if it were desired to run the web at a relatively slow speed at all times, it would be possible, as soon as the apparent defect was sensed, for an operator to visually inspect that portion of the web and thereby distinguish between apparent and actual flaws. However this would obviously require objectionably slow operation.

It is an object of this invention to provide a web inspection system wherein the web may be moved past defect sensing apparatus at an inspection station at relatively fast speeds and, when an apparent flaw is sensed, the web will be caused to come to a stop and then to reverse its travel, so as to bring the web back to a position wherein the apparent flaw-containing area of the web is once again substantially at this station where it may be re-inspected.

A further object of this invention is to provide such a system wherein, when a second apparent flaw is sensed during the interval required for the web's forward motion to be stopped after detection of a first apparent flaw, the second flaw will be rendered ineffective to control the web stopping during reverse movement so that, in such case, the web will return all of the way to the position wherein the first of said flaws may be reinspected.

Further objects of this invention will be apparent from the following description and claims, particularly when considered in the light of the accompanying drawing, wherein:

FIG. 1 is a diagrammatic showing of my improved web inspection system;

FIG. 2 is a block diagram of an automatic stop, memory control unit incorporated in my control system; and,

FIG. 3 is a schematic diagram of the motor control unit incorporated in my improved inspection system.

As shown in FIG. 1, my invention is illustrated as being applied to a web defect sensing apparatus wherein

2

a web 1 to be inspected is fed from a supply reel 2 over suitable guide rollers 3, 3' and an inspection drum 4 and to a take-up reel 5. Drum 4 is adapted to be driven, normally at a relatively high peripheral speed, by a suitable reversible motor 6 as indicated by the dash line connection 7. Positioned adjacent the inspection roller 4 is a defect scanner 8 which, as indicated at 9, is arranged to continuously scan the surface of the web 1 as it moves about the drum 4 to inspect it for defects therein. Such scanners are well known in the web inspection art and may, for example, be of the general type shown and described in my U.S. Patent No. 2,719,235. So far as the present invention is concerned, all that is necessary to be described relative to this scanner is that, when a defect in the web 1 is sensed, an output pulse will appear at the terminal 10 thereof and a defect relay D, incorporated therein, will be energized to initiate stopping of the web driving motor 6 and/or to sound a suitable alarm (not shown). Defect scanner 8 may also conveniently be provided with a suitable manual reset button 11 which may be utilized to restore the scanner and its relay D to normal condition ready for detecting subsequent defects.

Motor 16 is provided with a generally conventional motor control unit 12 having manual start, stop, forward and reverse push-button switches 13 to 16 respectively. The motor control unit 12 is connected to the field and armature of motor 6 as indicated at 17. As will later be described in more detail, motor control unit 12 is also connected as at 18 to certain contacts D1 of the defect relay D of scanner 8 and, as indicated at 19, to certain relay contacts L1 and S1 on low speed and stop control relays L and S incorporated in an auto-stop memory unit 20.

The auto-stop memory unit 20 provides means in conjunction with the defect scanner and motor control unit so that when a defect is sensed the drive motor 6 will slow down and stop and will thereupon automatically reverse and come to a final stop such that the defect in the web will once again be substantially opposite the defect scanner 8 where it may be more carefully examined. Basically, and as is more clearly shown in FIG. 2, the memory unit 20 includes a reversible shift register which, in effect, keeps track of how far the web has traveled past the scanner 8 after a defect has been sensed and until the forward motion of the web has stopped and then causes the stopping of the reverse movement of the web when the web has moved the corresponding distance in the reverse direction. This is done by entering a signal derived from the first defect pulse from defect scanner 8 into the first stage SR1 of the shift register 21 and then causing the stored signal to be advanced, stage by stage, once for each revolution of guide roller 3'. When the motor stops and starts to rotate in the opposite direction, the stored pulse will be shifted, stage by stage in the reverse direction through the shift register 21 serving to cause the drive motor to slow down as the previously sensed defect is neared, and to finally stop when the defect is returned to scanning position. The revolutions of the guide roller 3' may conveniently be sensed by a photoelectric unit including a disk 22 mechanically coupled to roller 3' as indicated at 23 and which is provided with an opening 24 therethrough which is adapted to be swept successively, during each revolution of the disk, across between a lamp 25 and each of a pair of angularly displaced photocells 26 and 27. As is later described, the pulses from photocells 26 and 27 conjointly serve to produce a register shift pulse, once each revolution of disk 23.

The direction of shifting of a stored pulse in the shift register 21 is controlled in accordance with the actual

direction of rotation of motor 6. To this end, a suitable direction-sensing switch DS is operatively connected to motor 6 as indicated at 7' and is provided with a movable contact 30 and a pair of spaced contacts 31 and 32. The arrangement of this switch should be such that when motor 6 is at rest, or is rotating in the reverse direction, contact arm 30 will be biased into contact with upper contact 31 whereas when (and only when) the motor is rotating in the forward web-feeding direction the contact arm 30 will be shifted into contact with lower contact 32. Switches of this general type, capable of producing this result are well known in the switch art and no detailed description thereof is deemed necessary. A suitable switch may, for example, be of the type provided with a spring (not shown) lightly biasing the contact 30 against contact 31 and arranged so that friction drag produced when the actuating shaft 7' is rotating in the forward direction, will tend to overcome this spring bias so as to reverse the contacts as described.

Defect pulses from terminal 10 of scanner 8 are applied to the memory unit 20 via input terminal 10', while reset of the memory unit may be conveniently produced by applying to reset terminal 11' thereof, a reset pulse derived from the reset button 11 on the defect scanner 8. Slowing down and final stopping of the motor 6 while the latter is operating in the reverse direction are controlled respectively by the previously mentioned low speed relay L and stop relay S incorporated in the memory unit.

The auto-stop memory unit 20 is shown in more detail in block diagram form in FIG. 2 wherein the shift register 21 is shown as comprising, for example, forty storage stages SR1-SR40 respectively. As previously mentioned the shift register 21 is of the reversible type, that is a pulse stored in any stage thereof may be shifted either to the right or to the left, depending upon whether a shift pulse is applied to the forward shift terminals 35 or to reverse shift terminals 36. Shift registers of this type are well known in the art and may comprise a plurality of bi-stable storage units suitably interconnected with one another. Such a register as that shown and described in Hemphill U.S. Patent No. 2,863,138, for example, would be suitable for this purpose. In the block diagram of FIG. 2 only the signal pulse input terminal 37 of the first stage SR1 is specifically identified since this is the only stage to which an external input signal need be applied. Each stage is also provided with a reverse shift output terminal 38 at which there will appear an output pulse each time a stored signal pulse is shifted out of that stage in the reverse direction, that is, to the left in FIG. 2. Here again, only those output terminals to which external connections are made are specifically identified in FIG. 2, the output terminal 38 of stage SR1 being used to trigger a pulse stretcher or generator 39, which may be in the form of a conventional monostable multivibrator and the output of which in turn serves to energize stop relay S. Where it is desirable, as in the present case during reverse operation, to insure that the final stopped position of the web be precisely controlled, it is preferred to initiate a slow-down operation somewhat prior to the actual stop signal. Therefore one of the intermediate stages, such as stage SR9, may conveniently have its reverse output terminal 40 connected to a pulse stretcher or generator 41 to, in turn, control the energization of the low speed relay L.

As previously mentioned, when a defect is sensed, a pulse or signal is applied as at 10' to the first stage input terminal 37 of the shift register. However, it is desirable that only one defect signal or pulse should be present in the shift register at any one time. Therefore the defect pulse appearing at 10' is applied first to a bi-stable storage unit 45, which may be a conventional flip-flop or magnetic storage core, and which, in response to the application of a defect pulse thereto, is triggered from one stable state to another in which it is insensitive to further defect pulses. However an output pulse is produced during this

changeover and is applied as at 46 to the input terminal 37 of stage SR1, thereby effectively entering the defect pulse into the register. Storage unit 45 will however remain in its insensitive state until it is reset by the application of the final stop pulse from terminal 38 to its reset terminal 47.

The means for generating the register shift pulses from the outputs of photocells 26 and 27 is also shown in FIG. 2. As previously described as disk 22 rotates, the opening 24 sweeps past photocell 26 producing an output pulse therefrom which is amplified as at 50 and is applied to one input terminal 51 of a bi-stable storage element 52 which, like storage element 45, may, for example, be a conventional flip-flop or magnetic storage core. Shortly thereafter, the opening 24 will sweep past photocell 27 and the resulting output pulse therefrom will be similarly amplified by amplifier 53 and applied to the other input terminal 51' of storage element 52, resetting the latter. The act of resetting storage element 52 produces an output pulse which is applied as at 55 to a pulse stretcher or generator 54 which may conveniently be a monostable multivibrator of conventional construction. The output from pulse generator 54 will be a pulse of predetermined duration appropriate for use as a shift pulse for register 21, and will be applied through the appropriate contacts of direction switch DS to one or the other of the forward or reverse shift control lines 56 and 57 respectively. As previously described if, and only if, the motor is rotating in the forward direction, the shift pulse will be applied through the lower terminal 32 of switch DS to the forward shift terminals 35 of each stage of the shift register, causing any signal which happens to be stored in any particular stage therein to be shifted to the next stage to the right. If, on the other hand, the motor is stationary or is rotating in the reverse direction, the shift pulse will be applied by way of the normally closed upper contact 31 of switch DS and reverse shift line 57 to the reverse shift input terminals 36 of each stage, thereby causing shifting of any stored pulse to the left. While other arrangements could obviously be provided for producing a shift pulse for each revolution of the roller 3', the arrangement disclosed is most effective and assures that there will be one, and only one such pulse produced for any single revolution. As previously described the entire shift register may be restored to its normal, cleared position by application of a reset pulse by way of reset terminal 11' and reset line 58 to the reset terminals 59 of the various stages.

Turning now to FIG. 3, the motor control unit 12 may comprise a motor relay M and a reversing relay R for controlling the application and direction of current flow through the armature 6A and field 6F of the motor 6. In FIG. 3, to render the actual circuits involved more easily traced, the various relay contacts are shown physically separated from their associated actuating coil. However in each case, the same letter which is used to designate the relay coil, is also used with a numeral to designate the contacts for that same relay. Motor relay M is adapted to be energized from a source of alternating current represented by the supply lines 60, 61. Upon closure of the start switch 13 a circuit is completed through stop switch 14, the normally closed points S1 of the stop relay S, start switch 13 and the coil of relay M energizing this relay, which thereupon becomes self-holding by virtue of the resultant closing of its normally open points M1. Energization of relay M also closes the normally open points M2 which complete a circuit from line 60 through rectifier 64 and armature 6A of the motor 6 to line 61. The current through the field 6F of motor 6 is controlled by a conventional speed control unit 65 and the contacts R2 and R3 of reverse relay R. As shown in the diagram, when relay R is de-energized, the upper contacts of relay points R2 and R3 are closed, the phase of the resulting current through field coil 6F being such as to produce forward rotation of the motor.

Reversal of the direction of rotation is obtained when the relay R is energized to reverse its points R2 and R3. Obviously the details of the speed control unit per se have nothing to do with the claimed invention and any known type of speed control unit could be utilized. Thus speed control unit 65 may conveniently be a conventional thyatron type of speed control unit such as are well known in the motor control art and, for illustrative purposes only is shown as including a current controlling resistor 66 which is normally shunted by the normally closed points L1 of the low speed relay L. The arrangement should be such that, when resistor 66 is thus shunted, the motor will operate at normal running speed, whereas when the shunt is removed by energization of the low speed relay L, the motor will operate at slow speed.

Reversing relay R is normally de-energized and is adapted to be energized upon energization of the defect relay D which, in closing its normally open points D1, completes a circuit from line 60 through the manually operable forward switch 15, contacts D1 and the coil of relay R to line 61. Relay R is also self-holding by virtue of its holding points R1 which upon closing, shunt contacts D1. Manual control for reversing relay R is provided by means of the manually operable reverse switch 16.

Turning now to the operation of my control system, it will be considered that the motor 6 is stationary and that reset button 11 has been actuated to prepare the system for normal operation. When it is desired to start the apparatus, the operator will first press forward switch 15 to insure that reverse relay R is de-energized so that its contact R2 and R3 are in their normal or forward condition. He will then press start switch 13 which, as previously described will energize motor relay M to complete the circuit through the armature 6A of the motor, causing the motor to begin to drive in the forward direction. During each revolution of the guide roller 3' a shift pulse will be generated by the above-described operation of photocells 26 and 27 and, since the motor is assumed to be operating in its forward direction, these shift pulses will be cyclically applied to the forward shift line 56 and the forward shift terminals 35 of the various stages of the shift register 21. However there will be no signal stored in any of the stages of the shift register at this time and so these shift pulses will have no effect. Thus the web will come up to speed and will be pulled relatively rapidly past the scanner 8, which, as previously described, continually scans the surface thereof for unwanted defects.

When a defect is sensed by the scanning mechanism 8, a defect pulse will appear at terminal 10 and the defect relay D will be energized to close its contacts D1 and thereby energize the reversing relay R. This in turn will cause a reversal of the points R2 and R3 in the field circuit for the motor 6 thereby attempting to drive the motor in the reverse direction. However, due to the considerable inertia of the parts it will take an appreciable amount of time for the motor to come to rest and to actually reverse its direction of operation. Therefore the pulse appearing at terminal 10 is utilized to effectively keep track of the actual location of the flaw on the web. As previously described this defect pulse will set storage flip-flop 45 to its insensitive stable condition, thereby applying a signal pulse as at 46 to the input terminal 47 of the first stage SR1 of the shift register. As previously described, subsequent defect pulses will be ineffective to enter new signal pulses into the register 21 until such time as storage element 45 has been reset to its other stable state. Thus only one defect pulse, and that the first one sensed, will effectively be entered into the shift register.

While the motor and web are slowing down, the web will continue to travel an appreciable distance in the forward direction, rotating guide roller 3' and associated disk 22 and causing the continued generation of shift

pulses by pulse generator 54. Therefore, the signal initially entered into the first stage SR1 of register 21 will be cyclically shifted one stage at a time toward the right until such time as the forward motion of the web is halted. When this occurs the direction switch DS will shift its contact arm 30 into engagement with the upper contact 31 so that succeeding shift pulses will be applied to the reverse shift line 57 and terminals 36. Therefore, as the motor begins again to drive the web, now in the reverse direction, the stored signal will begin to shift, stage by stage, backward from whatever stage it had finally reached and toward the lefthand end of the shift register. When this stored signal is shifted to the left out of stage SR9, for example, the output pulse at terminal 40 thereof will trigger pulse generator 41 to energize slow speed relay L. As previously described, relay L will thereupon open its points L1 to cause the speed control unit 65 to slow down the speed of operation of the motor 6. The motor will continue to run in the reverse direction but at a slow speed until the stored signal appears at the output terminal 38 of the first stage SR1 of shift register 21 where, as previously mentioned, it will trigger pulse generator 39 to energize the stop relay S. Energization of stop relay S will cause its point S1 to open to de-energize the motor relay M bringing the entire unit to a halt. The output pulse from terminal 38 will also reset flip-flop 45 so as to render it once again responsive to defect pulses.

While, as previously described, the initial stopping, reversal and final stopping of the web drive motor 6 will normally be entirely automatically controlled, it is possible, by operation of the manual control switches 13-16 to over ride this automatic control at any time. Thus, regardless of the direction of rotation of the motor at any particular instant, pressing the stop switch 14 will de-energize the motor relay M to bring the motor to a halt. It can then only be restarted by manual operation of start switch 13 and, upon such restarting, will run in the same direction as it was running when last stopped. On the other hand, by manually operating the reverse switch 16 while the motor is running in a forward direction the motor may be caused to slow down and reverse its direction of operation. Conversely, as it is moving in a reverse direction, pressing of the forward switch 15 will again cause it to slow down and return to its forward direction of motion. If, while such manual control is being utilized, there is a defect signal stored in the shift register 21 it will merely be shifted back and forth in the register in accordance with the actual direction of movement of the motor (and web) and will become effective to cause an automatic stop only when it appears at the output terminal 38 of the first stage SR1.

From the above it will be apparent that my improved inspection control system, as above described, effectively retains the advantages of prior inspection control systems while, at the same time it overcomes certain disadvantages thereof. As has been mentioned in conjunction with the detailed description, considerable variation is possible in the individual elements which together constitute my control system without departing from the general principle of operation thereof. For example, it is obvious that more than one degree of low speed operation of the motor could be provided by the mere use of additional elements such as 41 and L connected to the output terminals of other stages of the shift register 21 together, of course, with corresponding modification of the speed control unit to provide more than two-speed operation. No attempt has been made to show the detailed circuitry which would be utilized in an actual system but it is believed that the requirements of the components and their interconnections have been set forth in sufficient detail to enable anyone familiar with the electronic or electric control art to select appropriate detailed circuitry. The arrangement specifically shown is intended for purposes of illustration only and many

changes and alterations could be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. In a web inspection system wherein a web is normally traversed in a forward direction past an inspection apparatus adapted to sense predetermined conditions in said web, and including drive means for so traversing said web, the improvement wherein said drive means is reversible and wherein said system includes control means for said drive means responsive to sensing of such predetermined condition by said inspection apparatus during forward movement of said web for causing said drive means to initiate a stopping and reversal of the forward movement of such web, means for effectively measuring the distance traveled in said forward direction by said web during the interval between said sensing of said predetermined condition and actual stopping of said forward movement, and means controlled by said measuring means upon said reversal of said web movement for again causing said drive means to stop said web when it has moved a corresponding distance in the reverse direction, said control means being rendered, in response to sensing of one such condition, non-responsive to subsequent such conditions sensed during said interval.

2. In a web inspection system wherein a web is normally traversed in a forward direction past a defect scanning unit and including drive means for so traversing said web, the improvement wherein said drive means is reversible and wherein said system includes control means for said drive means responsive to sensing of a defect by said scanning unit for causing said drive means to initiate a stopping and reversal of the forward movement of said web, a multi-stage reversible shift register having a signal input terminal associated with the first stage thereof and forward and reverse shift control terminals associated with each stage thereof, shift pulse generating means responsive to movement of the web in either direction for producing a series of shift pulses each representing movement of the web through a predetermined distance, means responsive to sensing of a defect by said scanning unit for applying a signal to said signal input terminal of said storage register for entry therein, means responsive to the direction of movement of said web for applying said shift pulses to the shift terminals for the corresponding direction to effectively shift said signal forwardly and then rearwardly stage by stage through said shift register in substantial correspondence to the movement of said defect relative to said scanning unit, and said control means including stop means responsive to reverse shifting of said signal from said first stage to stop further operation of said drive means.

3. A web feeding system comprising means for travers-

ing a web in either direction along a predetermined path, a reversible multi-stage shift register, means operative during forward movement of said web for substantially simultaneously initiating a stopping and reversal of such forward movement and entering a signal into the first stage of said shift register, means responsive to the amount and direction of movement of said web for cyclically shifting such entered signal stage by stage in the corresponding direction within said register as said web stops and reverses its movement, and means responsive to reverse shifting of said entered signal from a predetermined output stage of said register for terminating further movement of said web.

4. A web feeding system as in claim 3 wherein said predetermined output stage is also said first stage.

5. A web feeding system as in claim 3 including means responsive to reverse shifting of said entered signal from a second predetermined output stage for slowing down the reverse movement of said web prior to said reverse shifting of said entered signal from said first-mentioned output stage.

6. A web feeding system as in claim 3 wherein said means for entering a signal into said shift register includes means responsive to entry of the first such signal for rendering said shift register non-responsive to further such signals.

7. A web feeding system as in claim 6 wherein said last-mentioned means is also responsive to reverse shifting of said entered signal from said output stage to again render said register responsive to succeeding signals.

8. A moving web control comprising:
means to decelerate and stop a rapidly moving web in response to a stop signal,
means rendered operative in response to said stop signal for determining the deceleration distance,
means operative during said deceleration for generating a signal indicating said web has come to a stop,
and means responsive to said signal generating means and said distance determining means for reversing the movement of said web at a greatly reduced speed a distance equal to said deceleration distance.

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M. HENSON WOOD, JR., *Primary Examiner*.

ABRAHAM BERLIN, ANDRES H. NIELSEN, RAPHAEL M. LUPO, ROBERT B. REEVES, *Examiners*.

A. MCKEON, J. ERLICH, *Assistant Examiners*.