

Aug. 22, 1944.

W. D. COCKRELL

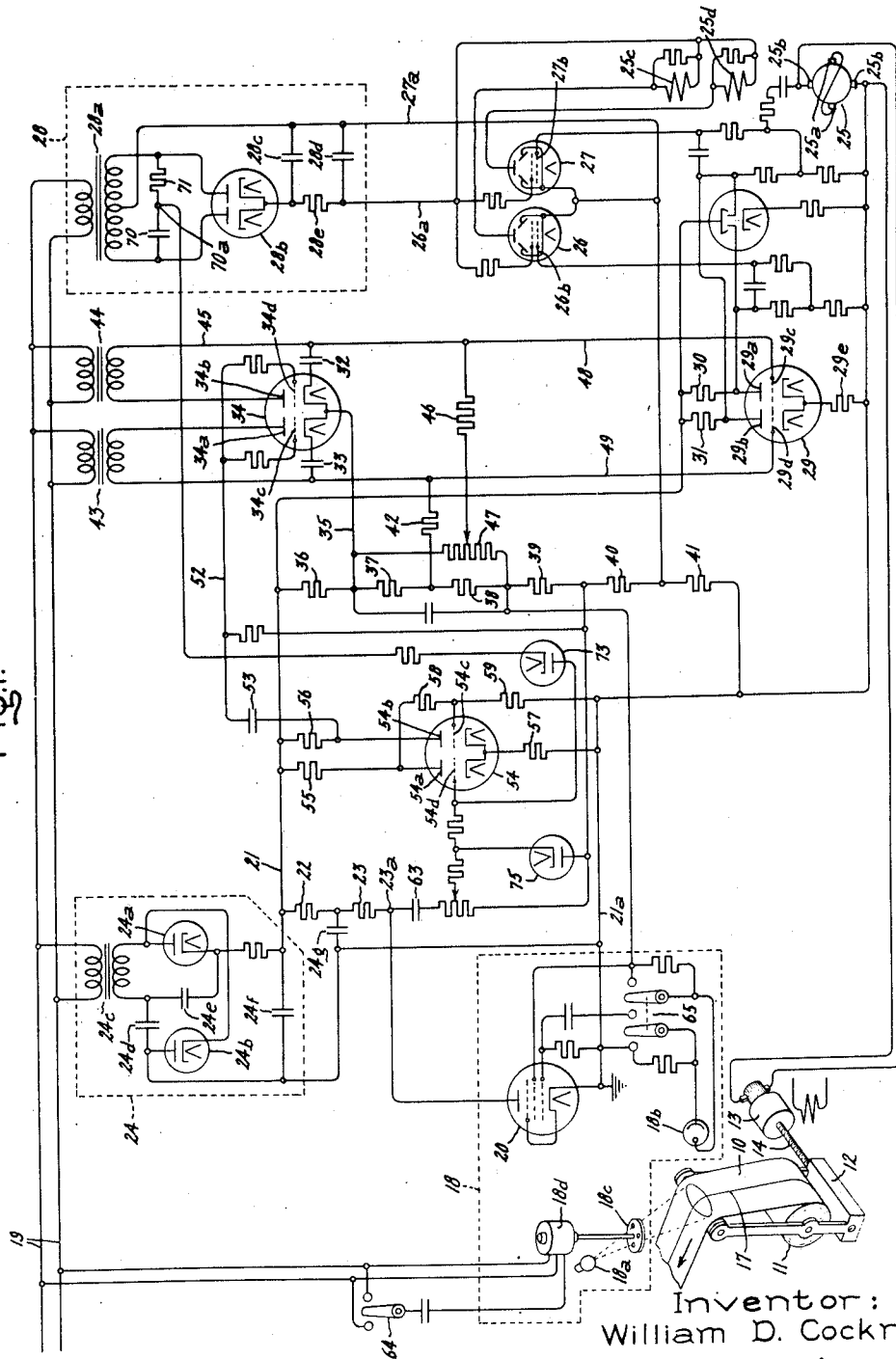
2,356,567

CONTROL SYSTEM

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2 Sheets-Sheet 1

Fig. 1.



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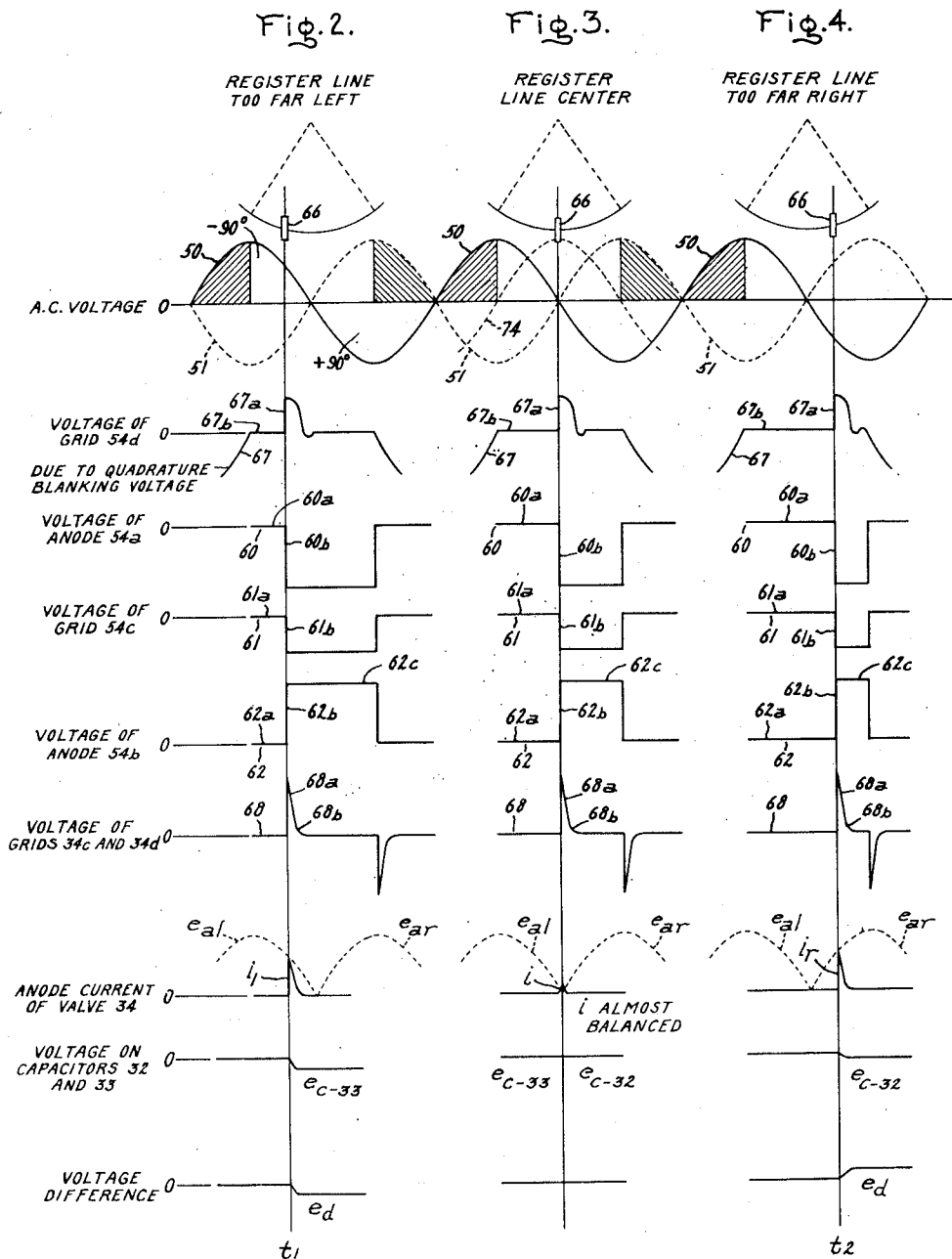
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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CONTROL SYSTEM

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Application October 16, 1941, Serial No. 415,205

9 Claims. (Cl. 271—2.6)

This invention relates to electric control systems, more particularly to control systems employing electric valves, and it has for an object the provision of a simple, reliable, and improved control system of this character.

In carrying out certain industrial operations, it is desirable to maintain a length of moving material, such as a web of paper, in a predetermined position laterally with respect to rollers or conveyors. It is also desirable in the carrying out of such operations that lateral deviations of the length of material from the correct position shall be speedily corrected and that such correcting action shall not result in sustained hunting or oscillation of the web with respect to the correct position, and a further and more specific object of this invention is the provision of an improved control system for maintaining lateral register of a length of moving material and substantially avoiding any tendency of the control system to produce hunting or oscillation of the web with respect to the correct lateral position.

Frequently in the carrying out of such operations as described in the foregoing, a pair of electric control circuits are employed for selectively effecting opposite operations, such for example, as the forward and the reverse operations of an electric motor. Such selective control is accomplished by operatively associating a different electric valve with each of these circuits and inducing dephased alternating voltages on the anodes of the valves thereby selectively to control the current transmitted by each valve in response to signal voltages impressed on the grids of the valves. When such apparatus is employed in conjunction with certain forms of error detecting devices, periodic false operation may result at certain times during each cycle of the alternating voltage. In order to eliminate this undesired false operation, means are provided for rendering each valve unresponsive to a signal voltage from the detecting device during those portions of the positive anode voltage of each valve in which it is possible for such false operations to occur.

In carrying the invention into effect in one form thereof, an electric motor is provided for effecting lateral movement of the length of material together with a control circuit for the motor having an electric valve operatively associated therewith. An electrical energy storage device is connected to the electric valve and means responsive to lateral misregister of the length of material are provided for controlling the electric valve to vary the amount of energy stored in the energy storage device in accordance with the amount of mis-

register of the length of material, and means responsive to the stored energy in the storage device are provided for controlling the motor to move the length of material laterally an amount proportional to the amount of the stored energy in a direction to correct the misregister.

For a better and more complete understanding of the invention, reference should now be had to the following specification and to the accompanying drawings in which Fig. 1 is a simple, diagrammatical illustration of an embodiment of the invention; and Figs. 2, 3, and 4 are charts of characteristic curves which serve to facilitate an understanding of the operation of the invention.

Referring now to the drawings, a length of material 10, such as a web of paper, is being delivered in the direction of the arrow to a machine or apparatus which performs an operation thereon, from a reel 11 from which it is being unwound. The reel is driven by any suitable driving means (not shown) such as an electric motor. The reel is mounted on a carriage 12 which is slidably mounted in ways (not shown) to provide for movement of the carriage at right angles to the length of the material. Suitable means, such as an electric motor 13 and a screw 14 driven thereby, are provided for moving the carriage along the ways in either direction.

It is desired to maintain the web 10 in a predetermined position laterally and in order to accomplish this, the web is provided with a fine register line 17, and a light sensitive means, such as a photoelectric scanning head 18, together with suitable electronic apparatus controlled thereby, is provided for controlling the electric motor 13 so as to maintain the position of reference line 17 in a predetermined lateral position.

The scanning head comprises the elements shown within the dotted rectangle 18. It includes a source of light 18a, a light sensitive device 18b, such as a photoelectric cell, a disk 18c carrying a plurality of lenses and a synchronous motor 18d for rotating the disk, and an amplifier valve 20. This scanning head detects the lateral deviation of the register line 17 from the predetermined correct position. It is a perfectly standard device and may be obtained on the market. For this reason, a description of the details and connections of its circuit is omitted. It is sufficient to understand that the anode-cathode circuit of the amplifier valve 20 is connected across a source of unidirectional voltage, illustrated as comprising the conductors 21 and 21a, from the positive side of the source 21 through resistors 22 and 23 to the anode and from the cathode to the negative

side 21_a of the source, that grid voltages are applied to its grids such that the valve is normally conducting, and that when the beam of light through one of the rotating lenses crosses the fine register line, the current transmitted by the valve is reduced, and the voltage of the resistor terminal 23_a correspondingly increased.

For the purpose of supplying unidirectional voltage to the supply lines 21 and 21_a, any conventional arrangement, such as the biphase rectifier shown within the dotted rectangle 24 may be employed. This rectifier comprises unidirectional conducting devices, such as electric valves 24_a and 24_b, a transformer 24_c having its primary winding connected to the source 19 and having the opposite terminals of its secondary winding connected to the anode of the valves 24_a and 24_b, together with capacitors 24_d, 24_e and 24_f connected in the manner shown. A filter capacitor 24_g is provided for further smoothing the rectified voltage to the scanning head. The particular circuit arrangement illustrated within the dotted rectangle 24 is known to the art as a voltage doubling circuit and it is so called because the magnitude of the D.-C. output voltage is substantially twice the magnitude of the alternating voltage impressed upon the primary winding of the transformer.

The electric motor 13 which moves the carriage 12 is supplied from a suitable controlled source such, for example, as the dynamoelectric machine 25. Dynamoelectric machine 25 is a special machine in that it is provided with a pair of short-circuited brushes 25_a and a pair of load brushes 25_b. The voltage across the load brushes 25_b is produced by the armature flux resulting from the current flowing in the short circuit. This type of machine is referred to as an armature reaction excited machine. As indicated, the machine 25 is provided with two opposing control field windings 25_c and 25_d, each of which when excited produces a flux along the axis of the load brushes 25_b of the machine. Among the advantageous characteristics of dynamoelectric machine 25 are its exceptionally high speed of response and its high amplification factor, i. e., the ratio between the current flowing in one of the control field windings 25_c or 25_d and the current flowing in the load circuit of the machine 25. The control field windings 25_c and 25_d are supplied with direct current from the supply lines 26_a and 27_a, and the amount of current supplied to the field windings 25_c and 25_d is controlled by electric valves 26 and 27, respectively. Preferably, the electric valves 26 and 27 are "hard" tubes of a type known to the art as a "beam" tube. As indicated, this type of tube is a tetrode and its structure is such that the anode may operate successfully at a minimum voltage positive with respect to the cathode. In the normal steady-state condition of the apparatus, i. e., the condition in which the fine register line 17 on the web 10 is in the correct lateral position, and no correction is being made, the grids 26_b and 27_b of the valves 26 and 27 are about equally negative with respect to cathode potential which causes both these valves to conduct equal amounts of current. Thus under these conditions, the field windings 25_c and 25_d are excited equally, and since these fields are opposing, the net excitation is zero and likewise the voltage across the load brushes is zero.

The unidirectional voltage is supplied to the supply lines 26_a and 27_a by means of suitable rectifying apparatus shown within the dotted

rectangle 28. This rectifying apparatus comprises a transformer 28_a having its primary winding connected to the alternating voltage source 19 and a two-way rectifying valve 28_b having its anodes connected to opposite terminals of the secondary winding of the transformer 28_a, together with a suitable filter comprising capacitors 28_c, 28_d, and a resistor 28_e. The cathode of the valve 28_b is connected to the conductor 26_a which thus becomes the positive side of the source of unidirectional supply and the midpoint of the secondary winding of the transformer 28_a is connected to the conductor 27_a which therefore becomes the negative side of the unidirectional source.

The control grids 26_b and 27_b of the power tubes 26 and 27 are respectively connected to the anodes 29_a and 29_b of an amplifier valve 29 which is illustrated as a twin triode valve having its cathode connected through a resistor 29_c to the negative side 21_a of the source of unidirectional voltage and having its anodes 29_a and 29_b connected through resistors 30 and 31, respectively, to the positive side 21 of the source of unidirectional voltage. The grids 29_c and 29_d of valve 29 are connected in circuit with capacitors 32 and 33, respectively. As shown, these capacitors 32 and 33 are connected to the cathode-anode circuits of an electric valve 34, illustrated as a twin triode valve. The purpose of electric valve 34 is to cooperate with the scanning head 18 in such a manner as to discriminate between misregister of the register line 17 to the left and to the right of the correct position and to vary the relative charges on the capacitors 32 and 33 in accordance with the direction and amount of such misregister. The anode-cathode circuit for the left-hand conducting path of valve 34 may be traced from the left-hand anode 34_a to the cathode, and thence by conductor 35 to a point on the voltage divider comprising resistors 36, 37, 38, 39, 40 and 41 connected in series across the unidirectional supply source 21, 21_a. The anode-cathode circuit is further traced from the junction point of the resistors 36 and 37 through resistor 37 and resistor 42 which is effectively in parallel with capacitor 33, and thence through the secondary winding of a transformer 43 to the anode. The primary winding of the transformer 43 is connected across the alternating voltage source 19. Similarly, the anode-cathode circuit of the right-hand conducting path of the valve 34 may be traced from the anode through the secondary winding of a transformer 44 and thence by conductor 45 and resistor 46 which is effectively connected in parallel with capacitor 32 to an adjustable contact on a resistor 47 connected across the resistors 37 and 38 of the voltage divider, and then through the upper portion of the resistor 47 to the conductor 35 and right-hand cathode of valve 34. Thus, the capacitor 32 is connected in parallel with resistor 46 in the anode-cathode circuit of the right-hand conducting path of valve 34, and likewise capacitor 33 is connected in parallel with resistor 42 which is included in the anode-cathode circuit of the left-hand conducting path of valve 34. The impedances of the voltage divider resistors 37, 38 and 47 are negligible compared to that of resistors 42 and 46. As a result, when current is transmitted through either one of the conducting paths of valve 34, the charge on one or the other of the capacitors 32 and 33 is varied in proportion to the current, and since the capaci-

tors 32 and 33 are connected by means of conductors 48 and 49 to the grids of amplifier valve 29, the latter amplifies the charges on the capacitors 32 and 33.

The grids 29c and 29d of valve 29 are also connected through resistors 42 and 46 to such points on the resistor 47 and on the voltage divider, respectively, that the grid voltages will cause both conducting paths of valve 29 normally to conduct predetermined equal amounts of current. The movable contact on the resistor 47 is provided for the purpose of making such adjustments as may be necessary to compensate for any inequalities in the conducting paths of the valve 29 and in the circuits between the valve 29 and the field windings 25b and 25a of the dynamoelectric machine 25 so that when the condition of correct register is present, both opposing control fields 25c and 25d will be equally excited and the dynamoelectric machine 25 will supply no current to the correcting motor 13.

The connections between the anodes of valve 34 and secondary windings of transformers 43 and 44 are such that the anode voltages are 180 degrees out of phase with each other, as indicated in Figs. 2, 3, and 4 in which curve 50 represents the voltage of the left-hand anode 34a and the dotted curve 51 represents the voltage of the right-hand anode 34b. Thus, except for a very narrow dead zone just prior to and following the instant of zero anode voltage, only one of the anodes of valve 34 will pass current at a time.

The grids 34c and 34d of the valve 34 are connected by means of a conductor 52 and a capacitor 53 to the right-hand anode of a twin triode valve 54. The function of the valve 54 is to amplify the voltage impulses received from the amplifier valve 20 of the scanning head 18 and to impress such amplified impulses on the grids of the discriminator valve 34. The circuit interconnections of the valve 54 cause it to have a square wave output voltage, i. e., one in which the current rises abruptly from zero value to maximum value and is cut off abruptly so that the current decreases rapidly from maximum value to zero value. This characteristic is brought about in the following manner. The anodes 54a and 54b are connected through resistors 55 and 56 to the positive side 21 of the d-c supply source. The cathodes are connected through a resistor 57 to the negative side 21a of the source. The left-hand anode 54a is connected through resistors 58 and 59 to the negative side 21a of the source. Thus the resistors 55, 58 and 59 constitute a voltage divider, and the right-hand grid 54c is connected to the junction point of the resistors 58 and 59, the voltage of which is of such a value that the right-hand path of the valve 54 normally conducts current when the left-hand path of the valve is non-conducting. If a positive voltage is applied to the left-hand grid 54d at a time when the left-hand path is non-conducting, the left-hand path will immediately begin to conduct current. Prior to the instant at which the left-hand path becomes conducting, the anode voltage is approximately at the same value as the positive side of the line and is represented by the height of the portion 60a of the curve 60 in Figs. 2, 3 and 4. The instant that the left-hand path becomes conducting, the voltage of the anode drops abruptly to a lower value owing to the voltage drop across the resistor 55. This decrease is indicated by the vertical portion 60b of the curve 60 in Figs. 2, 3 and 4. At the instant just prior to the beginning of

conduction on the left-hand path, the voltage of the right-hand grid 54c was at the maximum value represented by the height of the portion 61a of the curve 61 in Figs. 2, 3 and 4. The decrease in the voltage of left-hand anode 54a produces a corresponding decrease in the voltage of right-hand grid 54c and this is represented by the vertical portion 61b of the curve 61 in Figs. 2, 3 and 4.

Just prior to the decrease in the voltage of right-hand grid 54c, the voltage of right-hand anode 54b was at a reduced value owing to the voltage drop across the resistor 56 as represented by the height of the flat portion 62a of the curve 62 of Figs. 2, 3 and 4. The abrupt decrease in voltage of the right-hand grid 54c produces an equally abrupt termination of the conduction in the right-hand path of valve 54 and, consequently, the voltage of right-hand anode 54b rises equally abruptly to the voltage of the positive side of source 21. This condition is indicated by the vertical portion 62b of the curve 62, and the value to which the voltage of the right-hand anode rises is indicated by the height of the flat portion 62c of the curve 62. Likewise, when a negative voltage is applied to the left-hand grid 54d at a time when the left-hand path is conducting, the termination of conduction in the left-hand path and the reestablishment of conduction in the right-hand path is equally abrupt as indicated by the curves 60, 61 and 62. Thus, the valve 54 has a square wave output voltage characteristic.

As shown, the left-hand grid 54d of valve 54 is coupled by means of a capacitor 63 to the anode circuit of amplifier valve 20 of the scanning head.

Small size four-pole synchronous motors are comparatively inexpensive and easy to obtain. For these reasons the synchronous motor 18a which drives the lens carrying disk 18c may be assumed to be a four-pole motor. Since an electrical impulse must be transmitted by the photoelectric cell 18b to the correcting mechanism in timed relation with the anode voltages of the anodes 34a and 34b of valve 34, the synchronous motor 18a is therefore supplied from the same source as that from which the anode voltages of the valve 34 are derived, namely, the source 19. Owing to the fact that a four-pole synchronous motor may pull into step in any one of four positions, it is therefore necessary that the lens carrying disk 18c be provided with as many lenses as the motor has poles so that at a certain point in the cycle of the alternating voltages of anodes 34a and 34b, which point is preferably the zero point of the voltage wave, one of the four lenses will be in a position to transmit light from the source 18a to the area on the material 10 through which the register line 17 passes.

With the foregoing understanding of the apparatus and its organization in the completed system, the operation of the system itself will readily be understood from the following detailed description. The synchronous motor 18a is started by moving the movable contact of the switch 64 into engagement with one of its stationary contacts. The movable contacts of switch 65 are moved to the right into engagement with their cooperating stationary contacts.

If the register line 17 on the material 10 is in the correct lateral position, a beam of light through one of the lenses on the disk 18c will sweep across the register line 17 at the instant

that the positive voltage of anode 34_a and the negative voltage of anode 34_b pass through zero. This condition is indicated in Fig. 3 of the drawings in which the mark 66 represents the register line 17 and is located vertically above the zero point intersection of the curves 50 and 51. As the beam of light through the lens sweeps across the register line 17, the photoelectric cell 18_b is momentarily darkened and this causes the grid voltage of the left-hand grid 54_a of valve 54 to be momentarily increased as represented by the vertical portion 67_a of the curve 67 in Fig. 3. The initial value of the grid voltage before the increase is represented by the height of the portion 67_b of the curve and the final value after the increase is represented by the height of the vertical portion 67_a. This increase in grid voltage causes the left-hand path of the valve 54 to become conducting thereby causing the anode voltage of anode 54_a to decrease as represented by the portion 60_b of curve 60, and also causing the voltage of the right-hand grid 54_c to decrease as represented by the portion 61_b of curve 61. Simultaneously, the decrease in grid voltage of grid 54_c renders the right-hand path of the valve non-conducting so that the anode voltage of anode 54_b rises to the value of the positive line voltage as indicated by the vertical and horizontal portions 62_b and 62_c of the curve 62 in Fig. 3. The sudden increase in voltage of anode 54_b causes the capacitor 53 to charge and the charging current produces a steep rise in the voltage applied to grids 34_c and 34_d of the discriminator valve 34, as indicated by the steeply peaked portion 68_a of curve 68 in Fig. 3. The capacitor 53 preferably has a very small capacitance so that it is fully charged in an extremely brief interval of time. When the capacitor is fully charged the value of the grid voltage returns to the value of voltage existing at the junction point of resistors 39 and 40 of the voltage divider as indicated by the portion 68_b of curve 68. Since the positive voltage impulse is applied to both grids 34_c and 34_d at the instant of zero anode voltage, substantially no current will be transmitted by either conducting path of the valve 34. However, since the time required for the capacitor 53 to charge is a finite time, the grid voltage of grids 34_c and 34_d will be positive for a brief interval when either or both of the anode voltages are positive. Preferably, the apparatus is initially adjusted so that when the register line 17 is in the correct position laterally, the positive impulse of voltage applied to the grids 34_c and 34_d will begin just prior to the zero point of the anode voltages at a time when the voltage of anode 34_a is still positive and will terminate immediately after the zero point at a time when the voltage of anode 34_b has attained a positive value so that any conduction of the valve 34 resulting from the application of the positive voltage impulse to the grid will be equally divided between the two conducting paths. This condition is indicated in Fig. 3 of the drawings in which the dotted curve e_{a1} represents the voltage of anode 34_a and the dotted curve e_{a2} represents the voltage of anode 34_b, and the peaked curve i represents the current transmitted by the conducting paths. Since this current wave is equally distributed on opposite sides of the zero point, it is equally divided between the two conducting paths and the relative charge on capacitors 32 and 33 remains unchanged, which condition is represented by the two horizontal curves e_{c-32} and e_{c-33} indicating

equal charges on the capacitors. Consequently, there is no voltage difference of the capacitors to be amplified by the valve 29 and as a result, both opposing control field windings 25_c and 25_d of the dynamoelectric machine 25 remain equally excited and the dynamoelectric machine 25 supplies no current to the correcting motor 13.

However, if the register line 17 on the material becomes laterally displaced to the left, as indicated by the position of the mark 66 in Fig. 2, a positive impulse of voltage will be applied to the grids 34_c and 34_d at a time t_1 when the voltage of left-hand anode 34_a is still positive. As a result of the application of the positive impulse of grid voltage represented by the peaked portion 68_a of the curve in Fig. 2, the left-hand path of valve 34 becomes conducting for the duration of the interval of the impulse of grid voltage. The magnitude of the current transmitted by the left-hand path of valve 34 will be proportional to the magnitude of the anode voltage at time t_1 as indicated by the curve i_1 in Fig. 2. As a result, the capacitor 32 becomes charged as indicated by the curve e_{c-32} , and the difference voltage of the two capacitors 32 and 33 which is represented by the curve e_d in Fig. 2 is amplified by the valve 29 with the result that the conduction of power valve 26 is increased so that control field winding 25_c has a higher degree of excitation than control field winding 25_d and dynamoelectric machine 25 is caused to supply current to the correcting motor 13 in a direction to move the length of material 16 to the right toward the correct position. The amount of current that the dynamoelectric machine 25 supplies to the motor 13 is, of course, proportional to the amount of charge on the capacitor 33. This action will be repeated each time the proper lens on the disk 18_c passes between the light source 18_a and the material until the register line 17 has been restored to the correct position.

If the register line 17 becomes displaced from the correct position to the right, the operation will be similar but opposite in character to that described for misregister to the left. In other words, the impulse of positive voltage represented by the portion of the curve 67_a in Fig. 4 will be applied to grids 34_c and 34_d at a time t_2 when the voltage of anode 34_b is positive with the result that the right-hand path of the valve 34 will become conducting and transmit an amount of current proportional to the magnitude of the anode voltage at time t_2 as indicated by the curve i_2 in Fig. 4. This causes capacitor 32 to become charged as indicated by the curve e_{c-32} so that a difference voltage of the capacitors 32 and 33 represented by the curve e_d in Fig. 4 will be amplified by valve 29, and dynamoelectric machine 25 will be caused to supply a proportional amount of current to the correcting motor 13 in such a direction as to cause the register line to be moved to the left toward its correct position. This action will be repeated until the position of correct register is restored. With the apparatus as thus far described, it is possible for a false operation to occur. Since the disk 18_c carries four lenses, a signal voltage impulse will be supplied to the grids 34_c and 34_d at intervals separated by $\frac{1}{120}$ of a second or 90 electrical degrees of the alternating line voltage. Consequently, if the register line 17 is displaced to the left, a positive voltage pulse is supplied to the grids 34_c and 34_d when the voltage of anode 34_a is positive, and $\frac{1}{120}$ of a second later a second

positive pulse would be supplied to the grids when anode 34b is positive. Similarly, if the register line is displaced to the right, a voltage impulse is supplied to the grids 34c and 34d when the voltage of anode 34b is positive, and $\frac{1}{20}$ of a second later a second impulse would be supplied when the voltage of anode 34a is positive. This, of course, would produce a false operation. To eliminate the possibility of such false operation, means are provided for rendering the amplifier valve 54 unresponsive to signal voltage impulses from the scanning head during the second quadrant of positive voltage of anode 34b and during the first quadrant of positive voltage of anode 34a as indicated by the shaded portions of curves 50 and 51. These means comprise a capacitor 70 and a resistor 71 bridged across the midtapped secondary winding of transformer 28a; and a connection including an electric valve 73 from the junction point 70a of the capacitor and resistor to the grid 54a of amplifier valve 54. The voltage between the point 70a and the midtap of the secondary winding of transformer 28a which is connected effectively to the negative side 21a of the D.-C. source is in quadrature with the voltages of anodes 34a and 34b as indicated by the curve 74 in Fig. 3, and this quadrature voltage is supplied through the valve 73 to the grid 54a so that only the negative half of the quadrature voltage wave is effective. During the positive half cycle of this quadrature voltage, the voltage on the cathode of valve 73 is more positive than its anode and the valve does not conduct, and consequently, the voltage of grid 54a remains unaffected by the quadrature voltage. However, during the negative half cycle of quadrature voltage which coincides with the periods in which false operation can occur, as explained in the foregoing, the cathode of valve 73 is more negative than the anode and the valve conducts, thereby impressing a hold-off or negative voltage on the grid 54a which renders the grid 54a unresponsive to any signal voltage from the scanning head during these periods as indicated by the portion of the curve 67 below the zero axis in Figs. 2, 3 and 4.

Since this quadrature blanking voltage renders the grid 54a negative, it will be seen that it also acts as a resetting voltage for this tube after the left-hand path has been rendered conducting by a voltage impulse from the scanning head. The other diode 75 prevents any severe negative surge from the scanning head from resetting valve 54 too early and thereby eliminates this possibility of false operation.

Although in accordance with the provisions of the patent statutes, this invention is described as embodied in concrete form and the principle thereof has been explained together with the best mode in which it is now contemplated applying that principle, it will be understood that the apparatus shown and described is merely illustrative and that the invention is not limited thereto, since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of this invention or from the scope of the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A control system comprising in combination an electric circuit, a light sensitive electric valve included in said circuit, a pair of electric control circuits, apparatus for controlling the current in said circuits in response to the current trans-

mitted by said light sensitive valve having a pair of electron discharge paths each being operatively associated with a different one of said control circuits and each having a control grid, means for supplying dephased periodically varying voltages to said control circuits, and means responsive to current impulses transmitted by said light sensitive valve for impressing corresponding control voltage impulses simultaneously on said grids for selectively and continuously varying the transmission of current in said paths in accordance with the time phase relationship of said voltage impulses and said dephased voltages.

2. A control system comprising in combination, an electric circuit, a light sensitive electric valve included in said circuit, a pair of electric control circuits, apparatus for controlling the current in said circuits in response to the current transmitted by said light sensitive valve and comprising electric valve means having a pair of electronic discharge paths each being operatively associated with a different one of said control circuits and each having a control grid, means for impressing dephased periodically varying voltages on said control circuits, and means responsive to the current transmitted by said light sensitive valve for impressing a control voltage on said grids thereby selectively to control the transmission of current in said paths, and means for impressing a hold off voltage on said apparatus to render said electric valve means unresponsive to the current transmitted by said light sensitive valve during a portion of the positive half cycle of each of said periodically varying voltages.

3. A control system comprising in combination, an electric circuit, a light sensitive electric valve included in said circuit, a pair of electric control circuits, apparatus for controlling the current in said circuits in response to the current transmitted by said light sensitive valve and comprising electric valve means having a pair of electronic discharge paths each being operatively associated with a different one of said control circuits and each having an anode, a cathode and a control grid, means for impressing dephased alternating voltages on said anodes and means responsive to the current transmitted by said light sensitive valve for impressing a control voltage on said grids thereby selectively to control the transmission of current in said discharge paths and means for impressing a hold off voltage on said apparatus to render said electric valve means unresponsive to the current transmitted by said light sensitive valve during the period of increasing positive voltage of one of said anodes and during the period of decreasing positive voltage of the other of said anodes.

4. A control system comprising in combination, an electric circuit, a light sensitive electric valve included in said circuit, a pair of electric control circuits, apparatus for controlling the current in said circuits in response to the current transmitted by said light sensitive valve and comprising electric valve means having a pair of electronic discharge paths each being operatively associated with a different one of said control circuits and each having an anode, a cathode and a control grid, means for impressing substantially 180 degrees dephased alternating voltages on said cathodes and means for supplying a control voltage to said grids thereby selectively to control transmission of current in said paths, and means for impressing a hold off voltage on said grid voltage supply means to render said

electric valve means unresponsive to current transmitted by said light sensitive valve during the first quadrant of positive voltage of one of said anodes and during the second quadrant of positive voltage of the other of said anodes.

5. A control system comprising in combination, an electric circuit, a light sensitive electric valve included in said circuit, a pair of electric control circuits, apparatus for controlling the current in said circuits in response to the current transmitted by said light sensitive valve and comprising electric valve means having a pair of electronic discharge paths each being operatively associated with a different one of said control circuits and each having an anode, a cathode and a control grid, means for impressing substantially 180 degrees dephased alternating voltages on said anodes and means for supplying a control voltage to said grids thereby selectively to control transmission of current in said paths and means for impressing on said grid voltage supply means an alternating voltage in quadrature with said anode voltages thereby to render said electric valve means unresponsive to current transmitted by said light sensitive valve during the first quadrant of positive voltage of one of said anodes and during the second quadrant of positive voltage of the other of said anodes.

6. A lateral register control system for a length of moving material comprising in combination, an electric motor for effecting lateral movement of said material, a pair of electric control circuits for said motor, apparatus for controlling the current in said circuits comprising electric valve means having a pair of electronic discharge paths each being operatively associated with a different one of said circuits and each having an anode, a cathode and a control grid, a pair of capacitors each connected to one of said discharge paths, means for impressing alternating voltages on said anodes substantially 180 degrees out of phase and light sensitive means responsive to lateral misregister of said length of material in one direction for impressing a control voltage on said grids when one of said anode voltages is positive and responsive to misregister in the opposite direction for impressing a control voltage on said grids when the other anode voltage is positive thereby to control said valve means to selectively vary the charge on said capacitors, and means responsive to said selective variation of said charge for controlling said motor to move said length of material laterally an amount proportional to said charge in a direction to correct said misregister.

7. A lateral register control system for a length of moving material comprising in combination, an electric motor for effecting lateral movement of said material, a pair of electric control circuits for said motor, apparatus for controlling the current in said circuits comprising electric valve means having a pair of electronic discharge paths each being operatively associated with a different one of said circuits and each having an anode, a cathode and a control grid, a pair of capacitors each connected to one of said discharge paths, means for impressing alternating voltages on said anodes substantially 180 degrees

out of phase and light sensitive means responsive to lateral misregister of said length of material in one direction for impressing a control voltage on said grids when one of said anode

5 voltages is positive and responsive to misregister in the opposite direction for impressing a control voltage on said grids when the other anode voltage is positive thereby to control said valve means to selectively vary the charge on said capacitors, means responsive to said selective variation of said charge for controlling said motor to move said length of material laterally an amount proportional to said charge in a direction to correct said misregister, and means for applying a hold off voltage to said apparatus to prevent response to said light sensitive means during a portion of the positive half cycle of each of said anode voltages.

8. A lateral register control system for a length of moving material comprising in combination, an electric motor for effecting lateral movement of said material, a pair of electric control circuits for said motor, apparatus for controlling the current in said circuits comprising electric valve means having a pair of electronic discharge paths each being operatively associated with a different one of said circuits and each having an anode, a cathode and a control grid, a pair of capacitors each connected to one of said discharge paths, means for impressing alternating voltages on said anodes substantially 180 degrees out of phase and light sensitive means responsive to lateral misregister of said length of material in one direction for impressing a control voltage on said grids when one of said anode voltages is positive and responsive to misregister in the opposite direction for impressing a control voltage on said grids when the other anode voltage is positive thereby to control said valve means to selectively vary the charge on said capacitors, means responsive to said selective variation of said charge for controlling said motor to move said length of material laterally an amount proportional to said charge in a direction to correct said misregister, and means for supplying to said apparatus a hold off voltage in quadrature with said anode voltages to prevent response to said light sensitive means during a portion of the positive half cycle of each of said anode voltages.

9. A lateral register control system for a length of moving material comprising in combination, an electric motor for effecting lateral movement of said length of material, means for supplying current to said motor comprising an armature reaction excited dynamoelectric machine provided with a control field winding, an electric control circuit for said field winding and an electric valve included in said circuit, an electrical energy storage device operatively associated with said valve, means responsive to lateral misregister of said length of material for controlling said valve to vary the amount of energy in said storage device, and means responsive to the energy stored in said device for controlling said dynamoelectric machine to cause said motor to move said length of material laterally an amount proportional to the amount of said stored energy in a direction to correct said misregister.

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