

British Lugs. 544601 - 250-415.

Feb. 4, 1941.

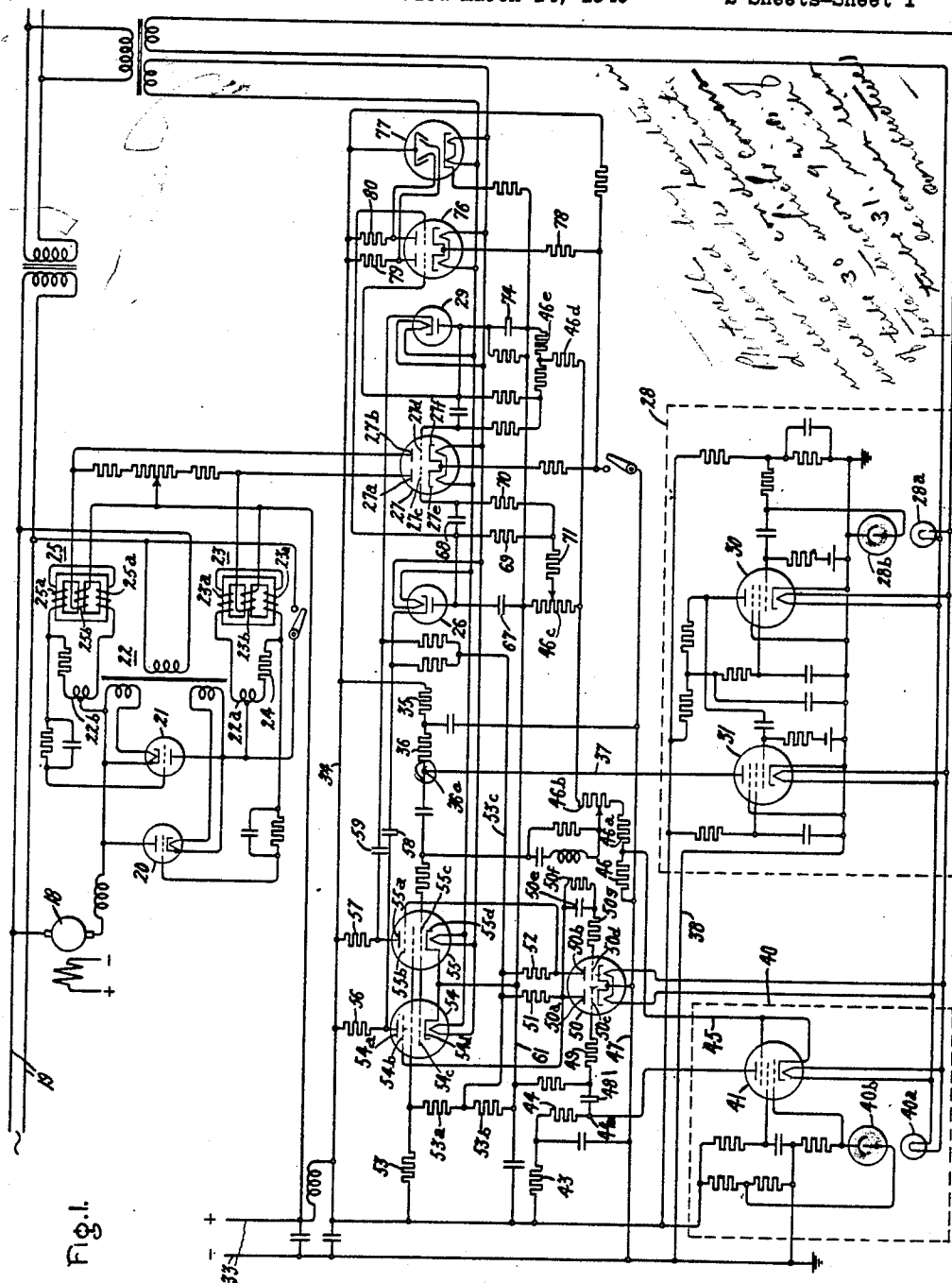
W. D. COCKRELL

2,230,715

CONTROL SYSTEM

Filed March 14, 1940

2 Sheets-Sheet 1



Inventor:
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His Attorney.

Cross Reference

250-201

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2 Sheets-Sheet 2

Fig. 2.

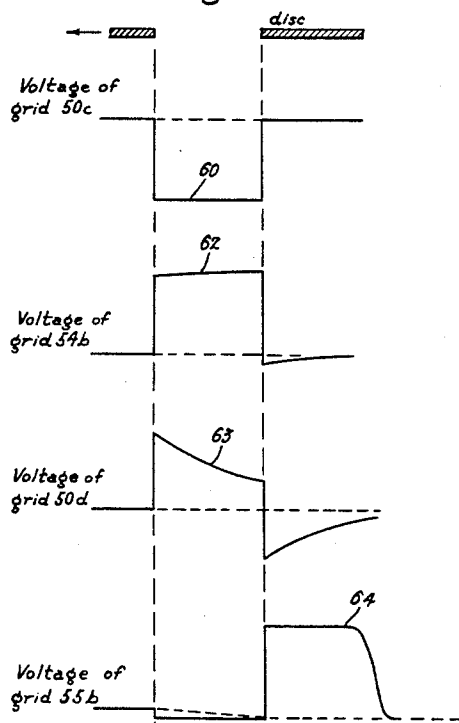


Fig. 3.

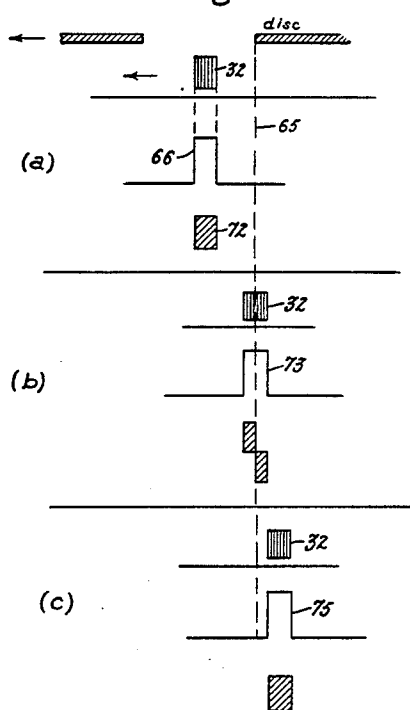
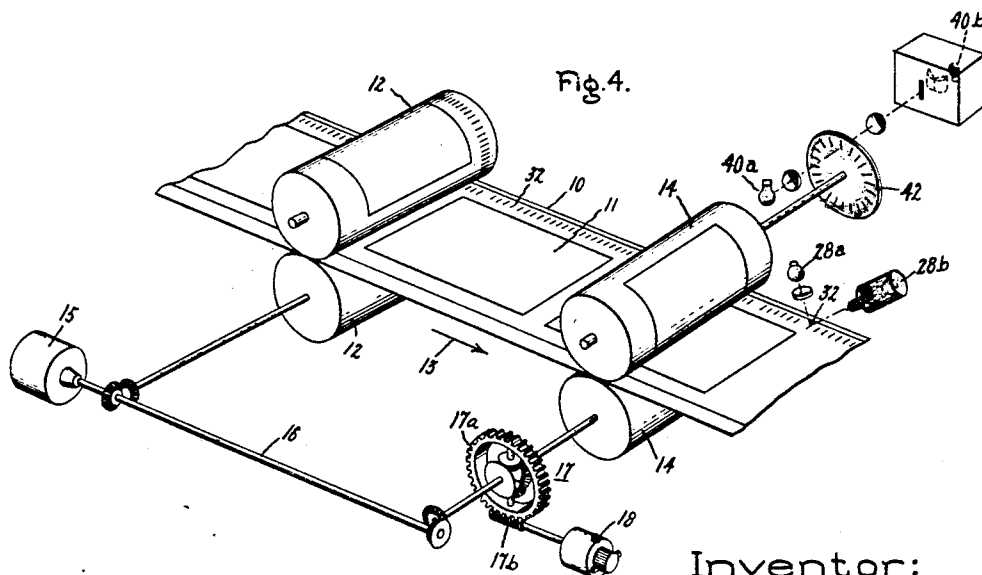


Fig. 4.



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UNITED STATES PATENT OFFICE

2,230,715

CONTROL SYSTEM

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Application March 14, 1940, Serial No. 323,884

8 Claims. (Cl. 271—2.6)

This invention relates to control systems, more particularly to systems for controlling the relative positions of a length of moving material and an element operating thereon so that the element performs its operations in register with marks, designs, or other matter which recur at predetermined intervals on the length of material, and an object of the invention is the provision of a reliable and improved system of this character.

More specifically, the invention is an improvement of the register control system disclosed and claimed in application Serial No. 304,996, for Control systems by David R. Shoults and William D. Cockrell, filed Nov. 17, 1939, and assigned to the same assignee. In application Serial No. 304,496, one of the controlling impulses which was instrumental in bringing about a correction of the misregister between the operating element and the length of material was produced by projecting light through a slot in a rotating disk driven by the operating element of the apparatus so that the image of the slot was projected toward a scanning head containing two spaced apart slits. A pair of photoelectric cells were mounted in the scanning head so that one received light passing through one of the slits and the other received light passing through the other slit. The space between the slits was slightly wider than the image of the disk slot as focused upon the scanning head by an optical system. Thus there was a brief interval or "dead zone" in which no correction would be made.

There are some classes of work in which the degree of accuracy required is so high that it is desirable to eliminate this "dead zone." One example of such class of work is multicolor gravure printing in which various superimposed colors are used. Accordingly, a further object of this invention is the provision of an improved register control system in the operation of which there is no "dead zone," thereby to obtain even greater accuracy of register than is obtainable with the system of application Serial No. 304,996.

Another object of the invention is the provision of a less expensive register control system and one having fewer parts than the system of the former application.

In carrying the invention into effect in one form thereof, light sensitive means are provided which respond to each of the register marks or indicia on a length of moving material to produce an electrical impulse, and additional light sensitive means are provided for producing another electrical impulse in accordance with the position of the operating element. In other

words, the time relationship of the occurrence of these impulses corresponds to the positional relationship of the designs on the material and the element which operates thereon. One of these impulses has a very sudden or abrupt termination. The initial arrangement of the parts is such that when the operating element is in exact register with the designs or matter on the moving length of material, a predetermined amount of the other impulse occurs just prior to the abrupt termination of the first impulse and a predetermined amount occurs just subsequent thereto. A very minute amount of misregister between the element and strip produces a change in the relative amounts of the second impulse occurring prior to and following the abrupt termination of the first impulse, and means responsive to these relative amounts are provided for affecting a correction in the relative positions of the element and the material.

In illustrating the invention in one form thereof, it is shown as embodied in a system for controlling the register between a color cylinder of a printing press and a color impression on the web printed at a prior point in the operation. It will be understood, however, that the invention has many other applications.

For a better and more complete understanding of the invention, reference should now be had to the following specification and to the accompanying drawings of which Fig. 1 is a simple diagrammatical illustration of an embodiment of the invention, Figs. 2 and 3 are charts of characteristics which facilitate an understanding of the operation of the invention, and Fig. 4 is a simple diagrammatical view in perspective of certain elements of the invention and certain elements of a gravure color press, and serves to illustrate the application of the invention to a printing press.

Referring now to the drawings, a length of material 10 such as web of paper having a color impression 11 printed thereon by printing cylinders 12 travels in the direction of the arrow to a succeeding element operating on the material, comprising a pair of printing cylinders 14 which print a second impression of a different color on the web. It is desired that this second color impression shall be made in exact register with the impression made by the cylinders 12. Although only two pairs of color impression cylinders are illustrated, frequently as many as four pairs are used in practice.

The printing cylinders are driven by suitable driving means illustrated as an electric motor 15

which is connected to the drive shaft of cylinders 12 by means of suitable gearing and to the drive shaft of cylinders 14 by means of suitable driving connections including shaft 16. It will be understood that any suitable means may be provided for varying the speed of motor 15 that the press may be operated at any desired speed.

A mechanical differential device 17 is included in the driving connections between motor 15 and cylinders 14. The ring gear 17a of this device is driven by a small direct current motor to which it is connected by means of worm gearing 17b. When the motor 18 is stopped, the pairs of cylinders 14 and 12 rotate at equal speeds.

The motor 18 receives armature power from any suitable source such as the constant voltage alternating current source represented by the supply lines 19. One armature terminal of the motor 18 is directly connected to one side of the source and the other armature terminal is connected to the other side of the source through a pair of reversely connected thyratrons and a transformer 22. A suitable phase shifting network is connected in the cathode grid circuit of each thyatron, and serves by varying the phase relationship between the grid and anode voltages to vary the conductivity of its operatively associated thyatron from a minimum to a maximum conductivity. The phase shifting network for thyatron 20 is illustrated as comprising the reactance winding 23a of a saturable core type reactor 23, the resistor 24 and transformer secondary winding 22a, and the network for thyatron 21 comprises the reactance winding 25a of saturable core reactor 25, and transformer secondary 22b. The direct current saturating windings 23b and 25b are supplied from a twin triode electric valve 27 having anodes 27a and 27b, grids 27c and 27d and cathodes 27e and 27f.

The control system is provided with a scanning head which comprises the elements within the dotted rectangle 28. It includes a source of light 28a, a light sensitive device 28b such as a photoelectric cell, and a pair of amplifier valves 30 and 31. This scanning head detects the passage of indicia or register marks 32 printed on the web 10 by cylinders 12 which print the first color impression. This scanning head is a perfectly standard device and may be obtained on the market. For this reason, a description of the details and connections of its circuits is omitted. It is sufficient to understand that the anode-cathode circuit of the last amplifier valve 31 is connected across a source 33, from one side of the source through conductor 34, resistors 35 and 36, conductor 37 to the anode and from the cathode through conductor 38 to the opposite side of the source, that grid voltages are applied to its control grids such that the valve is normally conducting, and that when an index mark passes the photoelectric cell 28b, the current through the valve and resistors 35 and 36 is reduced. As a result, the voltage of the resistor terminal 36a is increased.

A second scanning head which comprises the elements within the dotted rectangle 40 includes a light source 40a, a photoelectric cell 40b and an amplifier valve 41. This scanning head observes the motion of a disk 42 which is connected to the second pair of impression cylinders 14. This disk has a series of slots cut in it. The disk has the same number of slots as the number of register marks for one revolution of the impression cylinders. For example, sixteen marks

and slots per revolution are satisfactory for a web speed of 500 to 1000 feet per minute. These marks and slots must be equally spaced to an accuracy equal to or better than that of the error to be tolerated. A register mark .020" wide in the direction of paper travel and 1/2" long, and a disk slot width of 1/4", may be used. Register is held on the trailing edge of the slot.

The lamp 40a projects a beam of light through each slot in disk 42 as it passes between the lamp and photoelectric cell 40b. Preferably the scanning heads are so positioned that under conditions of correct register one-half of the electrical impulse produced by a register mark passing beneath scanning head 28 occurs before the trailing edge of a slot in disk 42 cuts off the beam of light and the remaining half of the impulse occurs after the trailing edge of the slot has cut the beam.

The scanning head 40 is also a perfectly standard device which may be purchased on the market, and therefore, a detailed description of its elements and circuit connections is omitted. It is sufficient to understand that the valve 41 is connected from the positive side of source 33 through resistors 43 and 44 to anode of valve 41 and from the cathode of valve 41 through conductor 45, resistor 46 and conductor 47 to the negative side of the source, that the voltages applied to its grids are such that the valve is normally conducting, and that when light falls on the photoelectric cell 40b, the current flowing in the anode-cathode circuit of the valve increases and lowers the voltage of the terminal 44a which is connected through capacitor 48 and resistor 49 to one grid 50c of a twin triode valve 50 having anodes 50a, 50b, grids 50c, 50d.

Both anodes of valve 50 are connected to the positive side of source 33, through resistors 51 and 52 respectively, and resistors 53, and 53a in series, and the cathodes are connected to the negative side of the source. Resistors 53, 53a, 53b, 46c, 46a, 46c, 46b, 46a and 46 form a voltage divider across the D. C. voltage 33 so that potentials along this divider remain substantially constant during the operation of the equipment. The voltages applied to grids 50c and 50d render both paths of the valve normally conducting. It will be noted that the anode 50a is connected through a timing circuit to grid 50d. This circuit comprises a capacitor 50e and parallel connected resistor 50f and a resistor 50g.

The anodes 50a and 50b of valve 50 are respectively connected to grids 54b and 55b of valves 54 and 55. These two valves are pentodes arranged for suppressor grid control so that if either the control grid or the suppressor grid is sufficiently negative, no current will flow in the anode circuit. The anodes 54a and 55a are connected through resistors 56 and 57, respectively, to the positive side of source 33, and they are also respectively connected through capacitors 58 and 59 to the cathodes of diode valves 26 and 29 while the cathodes 54a and 55a are connected to conductor 61.

Each time that the leading edge of a disk slot uncovers the beam from source 40a, the voltage of grid 50c of valve 50 is abruptly decreased and the left-hand path of the valve is rendered non-conducting, and when the trailing edge of the disk slot cuts off the beam, the grid voltage of grid 50c is abruptly increased and the left-hand path of valve 50 is again rendered conducting. This voltage impulse produced by the photoelectric cell 40b in response to the passage of a disk

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slot is illustrated in Fig. 2 in which the grid voltage is represented by the curve 60. Since no current flows to the anode 50_a during this impulse, the voltage of grid 54_b of valve 54 attains the positive voltage of conductor 61 as represented in the drawings by curve 62. It will be noted that this positive voltage impulse is coincident with the impulse produced by the photoelectric cell 40_b and that it also has an abrupt beginning and an abrupt termination. During this impulse, i. e. while its grid 54_b is positive, the valve 54 is prepared for conduction and will conduct if positive voltage is applied to the grid 54_a at any time during the impulse.

Also during this impulse capacitor 50_c whose upper terminal now has the positive voltage of conductor 53_c applied to it is charged by the grid current of grid 50_a. When the light beam is again cut off by the trailing edge of the disk slot and the left-hand path of valve 50 again becomes conducting, and current again flows through resistor 51, the grid 50_a will be made negative by the amount of the charge added to capacitor 50_c as indicated by the curve 63. It will be noted that the voltage of grid 50_a becomes negative coincident with or immediately following the abrupt termination of the voltage impulse produced by the photoelectric cell 40_a. As a result, the right-hand path of valve 50 becomes non-conducting, thereby applying a positive voltage to the grid 55_b of valve 55 and preparing valve 55 for conduction if a positive voltage is applied to grid 55_a in the manner explained in the foregoing with respect to valve 54. The capacitor 50_c begins to discharge immediately, but during this time the right-hand path of valve 50 remains non-conducting and valve 55 remains prepared for conduction as indicated by the curve 64 which represents the voltage of grid 55_b of valve 55. The ratios of the constants of capacitor 50_c and resistors 50₁ and 50₂ are so chosen that the times during which valves 54 and 55 are prepared for conduction are substantially equal at the average running speed.

Now assume that the impression cylinders 14 become out of register with the first color impression 11 so that the register mark 32 passes beneath scanning head 28, i. e. darkens photoelectric cell 28_b before the trailing edge of the corresponding slot in the disk 42 has cut off the light beam to photoelectric cell 40_b. This condition is shown graphically in Fig. 3 (a) in which the mark 32 is indicated as leading the trailing edge of the disk slot represented by dotted line 65 and in which the impulse of positive voltage produced by the photoelectric cell 28_b in response to passage of the register mark is represented by the curve 66. In other words, the impulse represented by curve 66 occurs during the period represented by curve 62 in which positive voltage is applied to the grid 54_b and the valve 54 is prepared for conduction. The impulse of positive voltage represented by curve 66 is applied to the grids 54_a and 55_a of both valves 54 and 55. Valve 54 begins to conduct, but valve 55 does not because it is not prepared for conduction at this time.

The flow of current through valve 54 produces a voltage drop across resistor 56 so that the anode 54_a becomes more negative than conductor 34 and since anode 54_a is connected by capacitor 58 to the cathode of valve 26, the cathode is driven negative with respect to its anode and begins to conduct and to charge up capacitor 67. The time which valve 54 remains conducting is equal to

the duration of impulse 65 which may be as short as $\frac{1}{1000}$ of a second. Such a period is far too short to obtain any successful operation of the thyratrons which supply the correcting motor 18. The pulses of current which are conducted by the diode 26 as long as the out of register condition obtains are stored in the capacitor 67. This permits the pulses to be changed to smaller voltage surges of longer duration, and also permits the integration of successive pulses. The capacitor then discharges through the semidynamic coupling comprising capacitor 68, and resistors 69, 70, and 71. This renders the grid 27_c of twin triode valve 27 more positive, and the left-hand path of valve 27 becomes more conducting so that more direct current is supplied to the direct current winding 23_b of saturable reactor 23 than is supplied to the winding 25_b of reactor 25. As a result of this unbalance, the phase of the grid voltage of thyatron 20 is advanced more with respect to its anode voltage as the phase of the grid voltage of thyatron 21 is retarded.

As a result the motor 18 is energized to run in a direction to restore register between the impression cylinders 14 and the first impressions 11 made by cylinders 12. The amount of correction due to each impulse produced by a register mark is represented in the drawings by the shaded rectangle 72. As long as this out of register condition exists, impulses produced by the register marks are supplied to the grid 54_a of valve 54 during the periods in which it is prepared for conduction and the motor 18 continues to correct until correct register is established.

If the impression cylinders 14 should become out of register with impressions 11 in the opposite direction so that a register mark 32 trails the trailing edge of the corresponding disk slot, an opposite correction will be made. This out of register condition is illustrated graphically in Fig. 3 (c). In this case the impulse 75 occurs after the beam to photoelectric cell 40_b has been cut off by the trailing edge of the corresponding disk slot and during that period represented by curve 64 (Fig. 2) in which valve 55 is prepared for conduction and valve 54 is not. Consequently valve 55 and diode 29 will conduct impulses which will charge capacitor 74. The charge on capacitor 74 will render the right-hand path of valve 27 conducting and this in turn will cause more direct current to be supplied to the saturating winding 25_a of reactor 25 than is supplied to the saturating winding of reactor 23. This results in advancing the phase of the grid voltage of thyatron 21 with respect to its anode voltage at the expense of the phase angle of the grid voltage of thyatron 20 and consequently, motor 18 is energized to run in the opposite direction from that previously described. As a result the speed of the impression cylinders 14 is temporarily reduced until correct register is restored.

When the impression cylinders 14 are in correct register with the first impressions 11, a predetermined portion of the impulse from the register mark occurs before the beam to photoelectric cell 40_b is cut off by the trailing edge of the corresponding disk slot and a predetermined portion occurs after the beam is cut off. This condition is illustrated in Fig. 3 (b) in which 50% of the impulse 73 is shown occurring prior to the cut off of the light beam, and 50% of the impulse is shown as occurring subsequent thereto. As a result both valves 54_a and 55_b are rendered conducting during the periods in which they are prepared for conduction, and the two saturable

reactors 23 and 25 are equally saturated by the currents flowing in both paths of valve 27. Both thyratrons 20 and 21 send current through the armature of motor 18 in opposite directions (on alternate half-cycles) for the same fraction of a half-cycle, and consequently the armature will not turn. However, it will vibrate slightly at the 60-cycle rate reducing the starting friction and thus providing very sensitive response to any unbalance in thyatron conduction.

In order to give a visual indication of the operation of the equipment, there is included the twin amplifier 76 in parallel with valve 27. The twin amplifier controls the electrodes of an indicator valve 77 in response to the variation of the grid voltages of valve 27. Since valve 76 is biased by the large cathode resistor 78, the sum of the currents in anode resistors 79 and 80 is equal to the current in resistor 78, but the division of the current and the relative anode potentials is controlled by the grid variations. Valve 77 is provided with an indicator face (not shown). When the impression cylinders 14 are out of register with the previous impressions 11, the current flowing through one pair of electrodes of the indicator valve 77 is larger than the current through the other pair. The indicator face has sectors before the pairs of electrodes. When the current through one pair of electrodes is larger than the current through the other pair, a first of the sectors is illuminated and the second is dark, indicating an out of register condition in one direction and when the opposite out of register condition is present, the first sector is dark and the second is illuminated. For the condition of exact register both sectors are evenly illuminated, but a slight fluttering pattern is observed in the illumination which is characteristic and enables the operator to know when exact register is present.

Although in accordance with the provisions of the patent statutes, this invention is described as embodied in concrete form and the principle of the invention has been explained together with the best mode in which it is now contemplated applying that principle, it will be understood that the elements and connections shown are 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 the 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 register control system for apparatus having an element operating on a length of moving material comprising light sensitive means responsive to an index mark on the material for producing an electrical impulse, light sensitive means controlled by said element for producing a second electrical impulse, one of said impulses having an abrupt termination, means for correcting the relative positions of said element and material, and means responsive to the relative amounts of the other of said impulses occurring before and after said abrupt termination for actuating said correcting means.

2. A register control system for apparatus having an element operating on a length of moving material in register with marks previously made thereon comprising means responsive to an index mark on the material for producing an electrical impulse, light sensitive means controlled by said

element for producing a second electrical impulse, means for correcting the relative positions of said element and said index mark one of said impulses having an abrupt termination, and means responsive to the occurrence of more than a predetermined amount of the other of said impulses prior to said abrupt termination for actuating said correcting means to make a correction in one direction and responsive to the occurrence of more than a predetermined amount of said other impulse occurring after said abrupt termination for actuating said correcting means to make a correction in the opposite direction.

3. A control system for apparatus having an element operating on a length of moving material comprising light sensitive means responsive to an index mark on said material for producing an electrical impulse, light sensitive means controlled by said operating element for producing a second electrical impulse, one of said impulses having an abrupt termination, a first electric valve prepared by said abruptly terminated impulse for control operation only during a period terminating with said impulse, a second electric valve prepared for control operation immediately following said abrupt termination, means for conducting the other of said impulses to said valves to initiate control operation of said valves in accordance with the relative amounts of said other impulse occurring prior to and following said termination, and means responsive to said control operation of said valves for correcting the relative positions of said element and material.

4. A register control system for apparatus having an element operating on a length of moving material having recurrent index marks previously placed thereon comprising light sensitive means responsive to each of said index marks for producing an impulse of control voltage, a light sensitive means controlled by said element for producing a second impulse of control voltage having an abrupt termination, means for correcting the relative positions of said element and said length of material, a pair of electric valves each having a pair of control grids and requiring the simultaneous application of voltage to both grids to render the valve conducting, means for supplying said second control voltage impulse to one grid of a first of said pair of valves to prepare said valve for conduction only for the duration of said impulse, means controlled by said first valve for applying a voltage to one grid of said second valve to prepare said second valve for conduction immediately following said abrupt termination for a period of time substantially equal to the duration of said second impulse, means for transmitting said first impulse to the other grids of both said valves to render said valves successively conducting for periods of time corresponding to the relative amounts of said first impulse occurring prior to and following said abrupt cut off, and means controlled by the current of one of said valves for actuating said correcting means in one direction and controlled by the current of the other of said valves for actuating said correcting means in the opposite direction.

5. A control system for apparatus having an element operating on a length of moving material having a plurality of index marks comprising in combination, light sensitive means responsive to each of said index marks for producing a control voltage impulse, light sensitive means controlled by said element for producing a second control

voltage impulse having an abrupt termination, a pair of electric valves each having a pair of control grids and requiring the simultaneous application of voltage to both grids to render the valve conducting, means for supplying said second control voltage impulse to the grid of one of said valves to prepare said valve for conduction for a period coincident with said second impulse, means controlled by said second impulse for supplying a voltage to a grid of the other of said valves to prepare said other valve for conduction immediately following said abrupt termination for a period of time substantially equal to the duration of said second impulse, means for transmitting said first voltage impulse to the other grids of both said valves thereby to render said valves conducting in succession for periods of time corresponding to the relative amounts of said first impulse occurring prior to and following said abrupt termination, and indicating means controlled by the currents of said valves for indicating the condition and direction of misregister between said element and matter previously placed on said length of material.

6. A register control system for apparatus having an element for performing an operation on a length of material and placing register marks on said material, and a second element for performing a second operation on said material in register with said first operation, comprising driving means and driving connections between said driving means and elements, correcting means comprising a mechanical differential device included in said driving connections and an electric motor for actuating an input member of said differential, light sensitive means responsive to each of said register marks for producing an electrical impulse, light sensitive means controlled by said second operating element for producing an electrical impulse, one of said impulses having a relatively abrupt termination, and means responsive to said impulses for actuating said correcting means an amount and in a direction determined by the relative amounts of the other of said impulses occurring prior to and following said abrupt termination.

7. A control system for apparatus having an element operating on a length of material having index marks thereon comprising a first pair of electric valves each provided with a pair of control grids and requiring the simultaneous application of voltages to both grids to render the valve conducting, a second pair of electric valves each provided with anode, cathode and control grid, means for applying voltages to the grids of said second pair of valves to render said valves conducting, the anodes of said second pair of valves being connected to the cathodes of said first pair of valves, and one grid of each of said first pair of valves being connected to the anode of the corresponding second pair of valves, voltage drop devices in the anode circuits of said second pair of valves whereby when one of said second pair of valves ceases to conduct a corresponding one of said first pair of valves is prepared for conduction, light sensitive means controlled by said operating element for producing a first electrical impulse, light sensitive means responsive to an index mark for producing a sec-

ond electrical impulse, one of said impulses having an abrupt termination, means for transmitting said abruptly terminated impulse to the grid of one of said second pair of valves thereby to render said valve non-conducting and to prepare the corresponding valve of said first pair for conduction for a period of time coincident with the duration of said impulse, a connection including a capacitor from the anode of the valve rendered non-conducting to the grid of the other of said second pair of valves whereby said other valve is rendered non-conducting and the corresponding one of said first pair of valves is prepared for conduction immediately following said abrupt termination for a period substantially equal to said abruptly terminated impulse, means for transmitting the other of said impulses to grids of both said first pair of valves whereby said valves are successively rendered conducting for periods of time corresponding to the amounts of said other impulse occurring prior to and following said abruptly terminated impulse, and means controlled by the currents of said first pair of valves for correcting the relative positions of said element and material.

8. A register control system for apparatus having an element operating on a length of moving material having index marks thereon comprising in combination, light sensitive means for producing an electrical impulse in accordance with the position of said element, light sensitive means responsive to each of said index marks for producing an electrical impulse, one of said impulses having an abrupt termination, a pair of normally conducting electric valves having voltage drop devices in their anode circuits, means for transmitting said abruptly terminated impulse to the control grid of one of said valves to render said valve non-conducting for a period coincident with said abruptly terminated impulse, a connection including a capacitor from the anode of said one valve to the grid of the other of said valves whereby said other valve is rendered non-conducting immediately following said abrupt termination for a period substantially equal to the duration of said impulse, a second pair of electric valves each provided with a pair of control grids and requiring the simultaneous application of voltage to both said grids to render the valve conducting, a connection from the anode of each of said first pair of valves to a grid of a corresponding valve of said second pair whereby one of said second pair of valves is prepared for conduction for a period coincident with said abruptly terminated impulse and the other is prepared for conduction immediately following the termination of said impulse and for an equal period, means for transmitting the other of said impulses to the other grid of each of said second pair of valves to render said valves successively conducting for periods of time substantially proportional to the relative amounts of said other impulse occurring prior to and following said abrupt termination, means for correcting the relative positions of said element and material, and means responsive to the currents of said second pair of valves for actuating said correcting means.

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