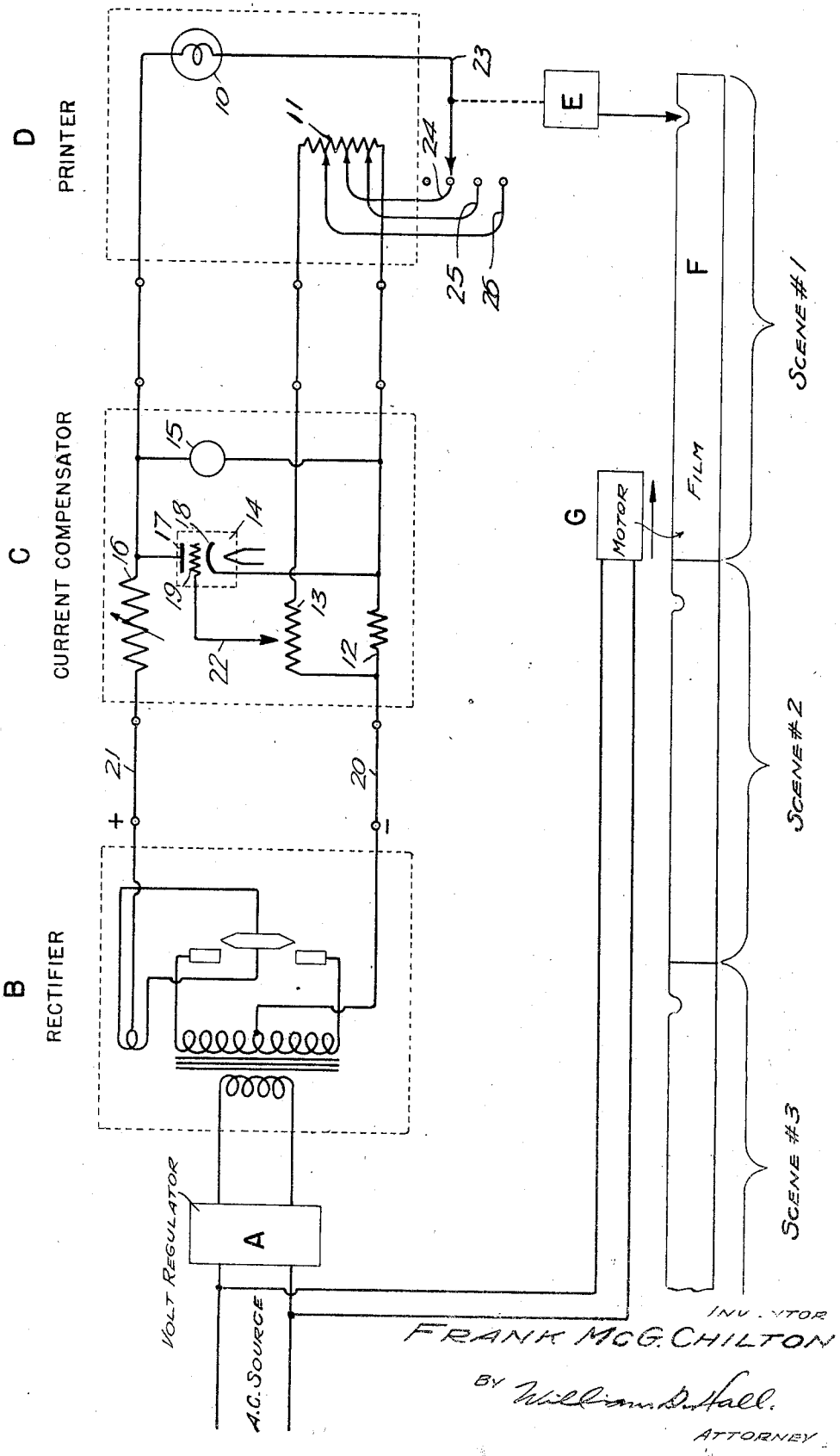
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CONTROL SYSTEM

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CONTROL SYSTEM

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to control systems and particularly to voltage control systems. It also relates to a system for controlling the brilliancy of the lamp in a film printing machine. The primary object of this invention is to provide means for accurately regulating the D. C. voltage across the lamp of a photographic printing machine and novelty resides in the regulator per-se and in the combination of such a regulator and the other parts of the photographic printing machine.

In certain types of photographic printing machines a rheostat is employed in series with the lamp and this rheostat is moved to various positions depending on the density of the film. Such a rheostat is accurately calibrated and for proper operation the supply voltage must be maintained accurately at a constant value. In some installations the variation in the rheostat adjustment affects the line voltage and hence the movement of the rheostat creates a greater change in voltage than it should create. The present invention overcomes this disadvantage and produces a system wherein the supply voltage remains substantially constant, whereby the accurate calibration of the rheostat is maintained.

A rheostat varies the current to the lamp and I provide a potentiometer connected across this rheostat. The drop across this potentiometer therefore varies inversely with the current in the lamp, hence when the current to the lamp decreases the drop across the potentiometer increases. This increased drop opposes and reduces the bias on a vacuum tube which has an anode and cathode respectively connected across the incoming line. When its bias is reduced, the tube becomes more conducting and effects a current flow from the source of supply to and through the tube but not through the lamp. The sum total current consumed by the lamp plus that consumed by the tube remains substantially constant, hence the voltage of the source of electricity remains constant notwithstanding the poor regulation of the current source. Hence the rheostat and lamp are operated from a constant supply voltage and the calibrations made thereof at the factory are not affected by changes in local line voltage.

In the drawing there is shown a system including seven main parts respectively indicated by reference letters. The voltage regulator A is connected across the incoming 115 volt A. C. sixty cycle line. The purpose of this regulator is to maintain the input voltage constant. In addition to the voltage regulator A, there is a rectifier B which converts the incoming voltage to a direct current voltage. Following the rectifier B in the circuit is a second regulator C which compensates for changes in the rectified D. C. voltage. The printer D has a lamp 10 (for printing the film) connected to the output of regulator C. The printer D includes an accurately calibrated rheostat 11 which is operated to different positions of adjustment by a notch-responsive means E, the latter being controlled by notches in the film F to be printed. The motor G is connected to the alternating current source and drives the film F at a constant rate of speed. The film F as shown, has been developed and has three scenes each of different film density and a notch placed at the beginning of each scene. The notch-responsing means E is constructed so that it moves the rheostat arm downward one tap in response to actuation by a notch. For example, the first notch causes the arm 23 to move from the uppermost tap into engagement with the tap 24. The rheostat arm 23 remains on tap 24, which gives the correct brilliancy for lamp 10 to print scene #1 of the film F, until the second notch reaches the notch-responsive means E whereupon the arm 23 moves to tap 25. The tap 25 is adjusted so when the rheostat arm 23 moves to it, lamp 10 has correct brilliancy for printing scene #2. The third notch is located at the beginning of scene #3 and when it reaches the means E the arm 23 moves to tap 26. This latter tap is positioned to give correct brilliancy for scene #3. Therefore the functional purpose of notch-responsive means E is to move the rheostat arm 23 to notches so positioned as to give such resistance in the lamp circuit that a proper brilliancy for printing the different scenes of the film will always be obtained. Hence the brilliancy of the lamp 10 is varied depending on the density of the film F. So far as this feature is concerned the idea disclosed is well known to the art and needs no more than a simple schematic illustration to convey the same to those skilled in the art. The rheostat 11 as normally produced and sold is very expensive and is accurately calibrated. It is calibrated to operate with a lamp such as 10 and at constant line voltages. However, I have found that when rheostat 11 is moved, the current is changed, and since the rectifier B has appreciable resistance there is an IR drop in the rectifier B that changes proportionately to the current to the lamp. If no means is provided to correct for this IR drop, the calibration of the rheostat 11 would then be in-

correct. In other words the change in position of rheostat 11 would cause a greater change in current at the lamp than contemplated if and when a rectifier B (or other current source) is used that has an IR drop varying proportionally to the current. While it would be possible to provide a rheostat 11 calibrated for each particular installation, I find it desirable to incorporate a regulator C to control the voltage and maintain a constant voltage on the input of printer D.

The regulator C comprises an adjustable resistor 16 which may be used for purposes of adjusting the voltage on the printer D manually to a predetermined value. The remaining parts of regulator C interact to hold the voltage at printer D to that value. A vacuum tube 14 (or when necessary to carry the current a plurality of such tubes connected in parallel) has its plate 17 connected to the positive side of the D. C. line and its indirectly heated cathode 18 to the negative side of the D. C. line. A resistor 12 of low resistance value is in series with the D. C. line and a potentiometer 13 of high resistance, say having a total resistance four hundred times the resistance of resistor 12, is connected between the wire 20 and the upper end of rheostat 11.

The principal current path from the rectifier B to and from the printer lamp is as follows: 21—16—10—11—12—20. However, some current does flow through the following path: 21—16—11—13—20. When the rheostat 11 is shifted, the current in potentiometer 13 varies.

The vacuum tube 14 has a grid 19 connected to the movable arm 22 of potentiometer 13. Hence a voltage is impressed between the grid 19 of the tube 14 and the cathode 18. This voltage varies with the current fed to the lamp. As will appear later, the voltage across the resistor 12 remains substantially constant at all times. The positive end of this resistor is connected to one end of potentiometer 13. The potentiometer 13 therefore, would effect a constant negative bias on grid 19 except for the opposing effect of the potential across potentiometer 13. The effective biasing potential on grid 19 equals the drop across resistor 12 less the opposing drop that occurs between wire 20 and arm 22 of potentiometer 13. This latter opposing drop varies with and depends on the current in potentiometer 13. The current in potentiometer 13 in turn depends on the position of arm 23 of rheostat 11. As the arm 23 moves to connect higher taps and increase the value of resistance in the lamp circuit, the current through potentiometer 13 increases hence the drop between 20 and 22 increases thereupon reducing the negative bias on grid 19, whereupon the current through tube 14 increases. When the arm 23 of rheostat 11 moves downward, the drop across potentiometer 13 decreases (the drop across potentiometer 13 is substantially equal to the drop from wire 20 to arm 23, since the resistance of 13 is large as compared to the resistance of rheostat 11). Hence as arm 23 moves downward, the potential across 13 decreases its opposition to the negative bias of resistor 12 and therefore, the tube 14 becomes less conducting and the shunting current through the tube is reduced.

By proper adustment of potentiometer 13 the total current consumed by the lamp 10 plus that consumed by the tube 14 thereafter automatically is held constant. In other words I^L+I_T equals a constant, where I^L is the current in the lamp and I_T is the current flowing from the cathode to the plate of the tube. Hence the voltage drop across the rectifier B as well as across resistors 12 and 16 remains constant for any given setting of variable resistor 16. Moreover, the voltage across the voltmeter 15 remains constant and the effect of a change in setting of of arm 23 does not create a greater change in current than that for which it is calibrated to create.

I claim to have invented:

1. A device for printing film comprising in combination with the film to be printed; a lamp for effecting printing of the film; a source of electrical supply; a rheostat in series with the source of electrical supply and the lamp; control means responsive to the densities of different scenes of the film for adjusting said rheostat to control the brilliancy of said lamp to effect thereby different printing brilliancies for the different scenes respectively; and means responsive to the control means for shunting current across the source of electrical supply; the last-named means including means whereby the sum of the current thus shunted plus that consumed by said lamp remains substantially constant when the rheostat is operated to change the current to the lamp.

2. In a device for printing film, the combination with a source of electrical supply, of a lamp operated from such source for printing the film, control means responsive to different densities of portions of the film for controlling the current to said lamp, and means operated by said control means for shunting current across said source to such degree that the sum of the shunted current plus the lamp curent remains constant when said control means varies the lamp current.

3. In a device for printing film, the combination with a direct current source of electrical supply of poor regulation whereby the voltage output therefrom varies when the load varies, of a lamp operated from said source, accurately calibrated rheostat means accurately controlled by the density of the film for varying the current through the lamp, and means associated with said rheostat means and affected by changes thereof for shunting current across said source in such quantity that the current drawn from said source remains substantially constant when the current through said lamp is varied.

4. In a device for printing film, a source of alternating current supply, a voltage regulator across said supply, a rectifier connected to the output of said supply, said receiver having characteristic of poor voltage regulation under varying load conditions, a lamp for printing a film connected to the output of said rectifier, rheostat means controlled by the density of the film for accurately controlling the brilliancy of said lamp when the film density varies, and means associated with and operated by the rheostat means to hold the current from the rectifier constant when the current to the lamp is varied by said rheostat means.

5. In a direct current voltage regulator, a two wire input; a discharge tube comprising a plate connected to one of said wires, a cathode connected to the other of said wires and a grid controlling the current through the tube; a two wire output respectively connected to the two wire input; a load; a rheostat in series with the load; a constant source of bias connected between the cathode and the grid of said tube to bias said grid negatively; and control means to oppose the negative bias including means con-

nected to said rheostat and responsive to the drop across the rheostat to increase the opposition to said negative bias when the drop across the rheostat increases and to decrease such opposition when the drop across the rheostat decreases; said tube and control means being so constructed and arranged that the sum of the current passed by the rheostat plus that passed by the tube remains substantally constant.

6. In a device for varying the current at a load without varying the current at the source of supply, the combination with the load and the source of a rheostat connected between the load and source for varying the current to the load to such an extent as to have very marked effect upon the operation of the load, current shunting means connected across said source, said current shunting means including control means thereof adapted for connection to a source of control potential for controlling the quantity of current shunted and means connected to said rheostat and responsive to the drop across the same and also connected to said control means to vary said control potential and thereby control the quantity of shunting current in such degree as to hold the current from the source constant when the load current is varied by said rheostat.

7. In a control device, a source of electricity of poor regulation, a load, a first wire leading from one side of the source to the load, a rheostat having two end connections and a movable arm connection, a second wire connecting the movable arm of the rheostat to the other side of the load, a resistor, a third wire connecting one end of said rheostat to one side of said resistor, a fourth wire connecting the other side of said resistor to the other side of said source, an electron discharge device having a grid, cathode and an anode, said electron discharge device constituting the only electron discharge device in or about said control device means connecting the cathode to said third wire, means connecting said anode to said first wire, a potentiometer having a movable tap, said potentiometer being connected from the fourth wire to the remaining end of said rheostat, and means connecting the movable tap of said potentiometer to said grid; the above named parts all being so constructed and arranged as to control the bias on said grid and effect a current shunted through said discharge device which effects a constant drain from said source when the rheostat arm connection is moved.

8. In a device for printing film, the combination with the film of a lamp operatively related with such film, means responsive to the density of the film for controlling the brilliancy of the lamp comprising a rheostat in series with the lamp; said rheostat having end terminals and movable tap; a tube having a cathode, a plate, and a grid; means connecting said tap to one terminal of the lamp; a resistor; a first wire connecting one of said end terminals to the first side of said resistor; a source connected to the second side of the resistor and also to the remaining terminal of said lamp; means connecting said cathode to said first wire; means connecting the plate to the said remaining terminal of said lamp; and means, comprising a potentiometer having its respective ends connected to the remaining terminal of said rheostat and to the second side of said resistor and including a movable tap connected to said grid, for controlling the quantity of current shunted by the tube to reduce the variation in current from said source when the rheostat tap is moved.

9. A voltage regulator as defined in claim 7 in which the rheostat functions to effectuate wide variations in load current.

10. The device defined in claim 5 in which said tube constitutes the only tube in the device.

11. The device defined by claim 6 in which the last-named means includes; wires connected directly to opposite ends of said rheostat and subject only to the drop across said rheostat, whereby the potential across said wires increases when the potential across the load decreases, and current shunting means for shunting current across said source to effect increased shunting when the potential across said wires increases and to effect decreased current shunting when the potential across said wires decreases.

12. In a direct current regulator, a two wire input; a discharge tube comprising a plate connected to one of said wires, a cathode connected to the other of said wires and a grid controlling the current through the tube; a two wire output respectively connected to the two wire input; a load; a rheostat in series with the load, said rheostat having wires connected to different points of same whereby to develop a potential across the wires depending on the setting of said rheostat; a constant source of bias connected between the cathode and the grid of said tube to bias said grid negatively; and control means to oppose the negative bias including means connected to said rheostat and responsive to the potential across said wires to increase the opposition to said negative bias when the drop across the rheostat increases and to decrease such opposition when the drop across the rheostat decreases; the last-named means including means to hold the sum of the current through said tube and rheostat substantially constant.

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