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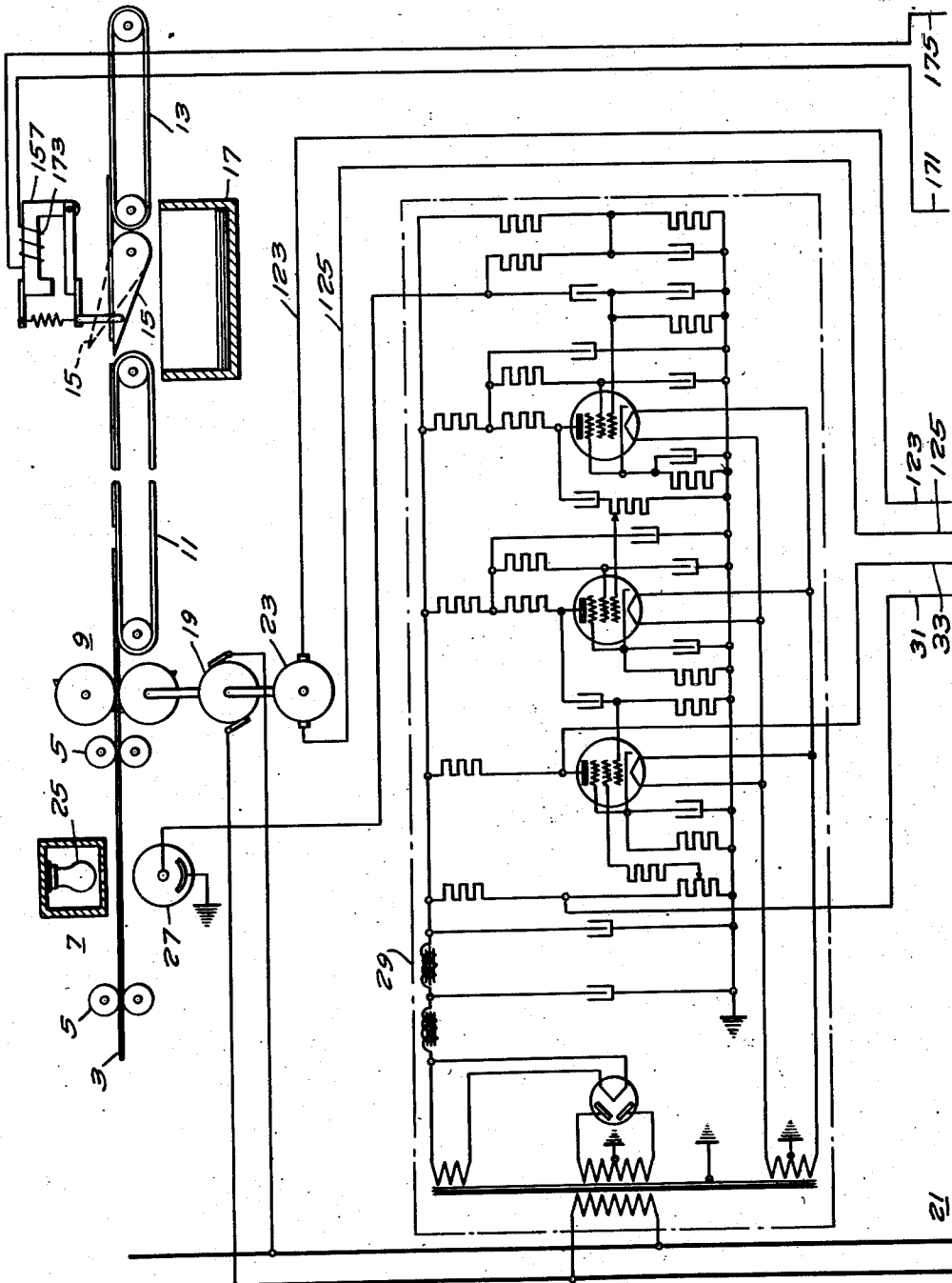
C. E. SMITH

2,387,952

ELECTRONIC TIMING SYSTEM FOR SORTING APPARATUS

Filed July 29, 1941

2 Sheets-Sheet 1



WITNESSES:

E. A. M. Lasky
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Fig. 10. 21

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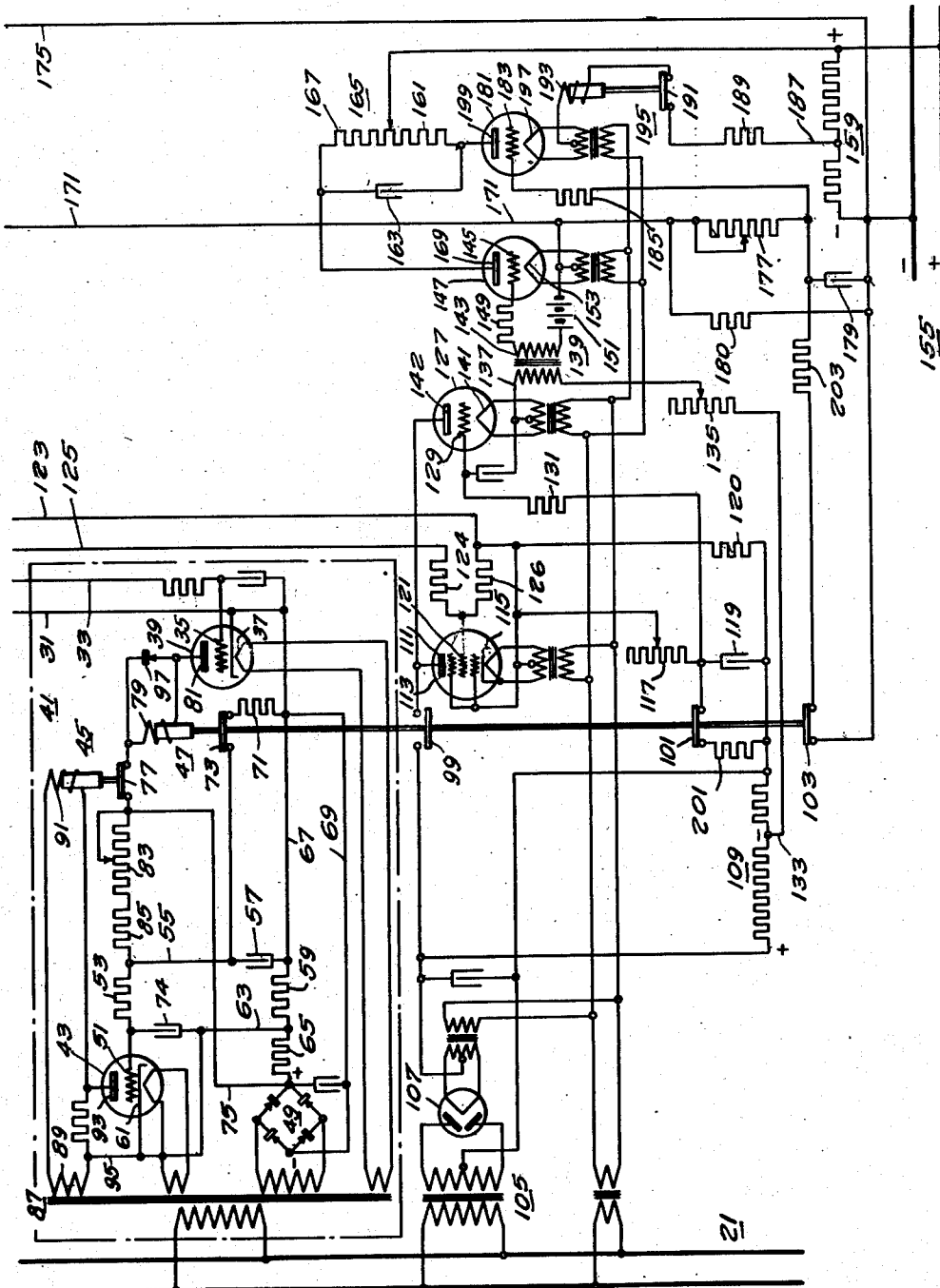
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2 Sheets-Sheet 2



WITNESSES:

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FIG. 16.

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ELECTRONIC TIMING SYSTEM FOR
SORTING APPARATUS

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Application July 29, 1941, Serial No. 404,527

11 Claims. (Cl. 250—41.5)

This invention relates to an electronic timing system, and has particular relation to apparatus for designating heterogeneous portions of moving material.

In certain industries, such as the canning industry, steel is supplied from the rolling mills in the form of a long continuous strip of sheet material. The strip is then fed to a shearing mechanism which cuts it into sections. Before reaching the shearing mechanism, the sheet material is passed through an inspecting device arranged to detect any pinholes which are present therein. On the opposite side of the shearing mechanism from the inspecting device is a diverting gate which is positioned adjacent the path of the moving sections of sheet material. The diverting gate is normally inoperative, permitting the sections of material to pass from the shearing mechanism to a storage bin or other apparatus, if desired. However, upon the detection of a pinhole, the inspecting device initiates operation of apparatus which causes the gate to be interposed in the path of the moving sections of material. After the gate has separated the section containing the pinhole, it is returned to its inoperative position.

The speed of the moving material varies over a wide range. It may be as low as 100 feet per minute or as high as 1000 feet per minute. Since the inspecting device and diverting gate are spaced from each other, the operation of the latter should occur a predetermined time after the detection of a pinhole, the length of the time interval being dependent upon the speed of the material. In apparatus constructed in accordance with the teachings of the prior art, considerable difficulty is encountered in obtaining precise and uniform timing of the operation of the gate. With irregular timing, the apparatus is sometimes arranged to separate a number of sections upon the detection of a single pinhole to insure separation of the heterogeneous section. The resulting waste of material is obviously undesirable.

It is accordingly an object of my invention to provide apparatus for accurately and consistently operating mechanism for designating heterogeneous portions of moving material.

Another object of my invention is to provide a novel apparatus for operating mechanism for designating heterogeneous portions of moving material in which the operation is timed with respect to the speed of the material.

An additional object of my invention is to provide apparatus for operating mechanism for

designating heterogeneous portions of moving material in which operation of the mechanism is initiated a time interval after the detection of a heterogeneity, the length of the time interval being dependent upon the speed of the material.

A general object of my invention is to provide apparatus for effecting operation of a load device in which the operation is timed with respect to the magnitude of a physical quantity.

An ancillary object of my invention is to provide a novel electrical circuit for timing the operation of a load device.

Another object of my invention is to provide apparatus for classifying and sorting moving material whose speed is variable in which the time of operation of a sorting device following inspection of the material varies inversely as the speed of the material.

Still another object of my invention is to provide apparatus for use in classifying and sorting moving material having different speeds which operates a sorting device when material of one classification has moved a predetermined distance from a classifying device regardless of the speed of the material.

A more specific object of my invention is to provide apparatus for sorting heterogeneous portions of moving material which includes means for properly operating a diverting gate at one location along the path of the material in response to the detection of a heterogeneity at another location.

In accordance with my invention as applied to the sorting of heterogeneous portions of moving material, I provide a charge-storing means, such as a capacitor, arranged to be supplied with charging current through an electric discharge device. The discharge device has a constant-current voltage characteristic over a substantial range of potential and the flow of current there-through is initiated upon the detection of a heterogeneity. The rate of flow of the charging current is controlled in accordance with the speed of the moving material. Consequently, the rate of charging of the storing means is dependent upon the speed of the material.

An electric discharge valve of the arc-like type is interposed between a source of direct-current potential and the operating means for the diverting gate. When the charge on the storing means attains a predetermined value, the valve is rendered conductive. A capacitor is also connected to the valve and when the latter is rendered conductive, charging of the capacitor begins at the

same instant that the operating means is energized. An auxiliary circuit is provided which includes means responsive to the charge on the capacitor for interrupting the conductivity of the valve. When the charge on the capacitor attains a preselected value, the valve is rendered non-conductive by the auxiliary circuit. The operating means is thus deenergized and the diverting gate is returned to its inoperative position.

From the foregoing, it is apparent that the time of energization of the operating means for the gate is dependent upon the time required to charge the storing means to the predetermined value. The charging time of the storage means in turn is dependent upon the speed of the material.

The period during which the operating means remains energized is constant regardless of the speed of the material, and is determined by the rate of charging of the capacitor. It is to be noted that once the leading edge of a section of the sheet material is diverted by the gate, that section is separated from the others even if the gate operating means is deenergized before the entire section passes the gate. The constants of the circuit for charging the capacitor are so set that the operating means remains energized for a period sufficient to separate the heterogeneous section at the slowest speed of the material. With precise and uniform timing of the operation of the gate, a constant period of energization of the operating means is permissible without an excessive loss of material.

The novel features that I consider characteristic of my invention are set forth with particularity in the claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings. In these drawings,

Figures 1a and 1b taken together form a diagrammatic view showing a preferred embodiment of my invention.

In the apparatus shown in the drawings, a strip of sheet material 3 is fed through rollers 5 past an inspecting device 7 to a shearing mechanism 9. The shearing mechanism cuts the material into sections which pass over a conveying system comprising a plurality of conveyors 11 and 13. A diverting gate 15 is located between the conveyors 11 and 13 and is normally in the position shown in full lines. Upon the detection of a pinhole by the inspecting device 7, the diverting gate 15 is raised to a position as shown by the dotted lines. The heterogeneous section is then diverted into a discard bin 17. After the separation of the heterogeneous section, the diverting gate is returned to its original position, permitting the material to pass from one conveyor to the other.

The speed of the material 3 is governed by the speed of the shearing mechanism 9. The means for driving the shearing mechanism is indicated symbolically by a motor 19 supplied from a source 21 of alternating-current potential. A generator 23 is also connected to the shearing mechanism, and the magnitude of the voltage generated thereby varies in accordance with the speed of the material.

The inspecting device 7 comprises a source of radiant energy 25 and a photosensitive device 27 positioned on opposite sides of the material 3. The photosensitive device may take the form of a

photoelectric tube or a number of photoelectric tubes connected in parallel. When a pinhole is present in the material, energy passes from the source 25 through the hole to the photosensitive device 27, and the latter causes an impulse to be transmitted to an amplifying system indicated generally at 29. The output of the amplifying system is impressed through leads 31 and 33 between the grid 35 and cathode 37 of a thyatron tube 39 forming part of a control unit 41.

The control unit 41 includes a second thyatron tube 43, a pair of current relays 45 and 47, and a source of direct-current potential 49. The control circuit of the second thyatron 43 may be traced from the grid 51 through a grid resistor 53, lead 55, a capacitor 57, a second resistor 59 and lead 63 to the cathode 61 of the tube. The end of resistor 59 which is connected to the cathode 61 is also connected through resistor 65 to the positive terminal of the source 49, and the other end is connected through leads 67 and 69 to the negative terminal of the source. As long as relay 47 is deenergized, the capacitor 57 remains uncharged because of a shunt circuit extending from one plate of the capacitor through lead 67, resistor 71 and contactor 73 of the relay 47 to the other plate. Thus, a negative grid-cathode potential exists in thyatron 43. A capacitor 74 is connected between the grid and cathode to cooperate with the other constants of the circuit in determining the grid-cathode potential at which thyatron 43 fires.

A detailed explanation of the amplifying system illustrated is not necessary to a complete understanding of my invention. It is sufficient that lead 31 is normally positive with respect to lead 33.

When the impulse initiated by the photosensitive device 27 passes through the amplifying system 29, lead 33 becomes positive with respect to lead 31, causing thyatron 39 to be rendered conductive. Current then flows in a circuit extending from the positive terminal of the source 49 through lead 75 normally closed contactor 77 of the relay 45, the coil 79 of the control relay 47 to the anode 81 of the thyatron 39. The circuit then continues from the cathode 37 of the thyatron through lead 69 to the negative terminal of the source 49. The control relay 47 is thus energized to open its contactor 73 in the circuit shunting the capacitor 57. The capacitor 57 is then charged through a circuit extending from the positive terminal of source 49, lead 75, variable resistor 83, resistor 85, lead 55, capacitor 57 and leads 67 and 69 to the negative terminal of the source. After a predetermined interval of time, the capacitor 57 is charged sufficiently to make the grid 51 positive with respect to cathode 61 and the second thyatron 43 is rendered conductive.

The thyatron 43 is connected in a circuit receiving potential from the alternating-current source 21 through an auxiliary transformer 87. The circuit extends from one terminal of the secondary 89 of the transformer 87 through the coil 91 of the relay 45 to the anode 93 of the thyatron 43 and continues from the cathode 61 through a lead 95 to the other terminal of the secondary. When the second thyatron 43 is rendered conductive, the relay 45 is energized to open its contactor 77 in the anode circuit of the first thyatron 39. A rectifier 97 is connected in circuit with the coil 79 of the control relay 47 to effect complete deenergization thereof when thyatron 39 becomes non-conductive. It is then apparent

that the control relay 47 is energized upon the detection of a pinhole, and is deenergized a predetermined time later.

In addition to the contactor 73 in the control unit, the control relay 47 operates three other contactors 99, 101 and 103 in a timing system. A direct-current potential is provided for the timing system from the alternating-current source 21 through an auxiliary transformer 105 and a rectifier 107 connected to a voltage divider 109. When the control relay 47 is energized, its contactor 99 closes to complete a circuit from the positive terminal of the voltage divider 109 through the contactor 99 to the anode 111 of an electric discharge device 113. The circuit continues from a cathode 115 of the device 113 through a variable resistor 117 and a capacitor 119 to the negative terminal of the voltage divider 109 and a bleed resistor 120 is connected across the resistor 117 and capacitor 119.

The electric discharge device 113 is of the type through which the current flow is independent of the anode-cathode potential. For this device a pentode, designated commercially as a RCA-58 tube, is preferred. While the current flow through the pentode 113 is independent of the anode-cathode voltage, it is dependent upon the potential impressed between one of its grids 121 and the cathode 115. Over a portion of the characteristic of the pentode, the current flow between the anode 111 and cathode 115 is directly proportional to the potential impressed between the grid 121 and cathode 115. It is along this portion of the characteristic that the pentode is operated. The potential of the generator 23 is impressed through a pair of leads 123 and 125 between the grid 121 and cathode 115 of the pentode. A grid resistor 124 is connected between the grid 121 and lead 125 and resistor 126 ties the grid 121 to cathode 115. Thus, the flow of current through the pentode is dependent upon the speed of the moving material. It is evident that the capacitor 119 in circuit with the pentode will be charged at a rate which is also dependent upon the speed of the material.

The capacitor 119 is included in the control circuit of another thyatron tube 127. This thyatron is preferably a Westinghouse KU-627 tube. The control circuit extends from the grid 129 of the thyatron 127 through a grid resistor 131 and the capacitor 119 to the negative terminal of the voltage divider 109. The control circuit continues from an intermediate tap 133 on the divider 109 through a variable resistor 135 and the primary 137 of an impulse transformer 139 to the cathode 141 of the thyatron 127. The portion of the voltage divider 109 in the control circuit causes a negative potential to be impressed between the grid 129 and cathode 141 of the thyatron 127. However, when the charge on the capacitor 119 in circuit with the pentode 113 attains a predetermined value, it counteracts the negative biasing potential and causes the thyatron 127 to become conductive. Current then flows from the positive terminal of the voltage divider 109 through the contactor 99 of the relay 47, the anode 142 and cathode 141 of thyatron 127, the primary 137 of the impulse transformer 139 and the variable resistor 135 to the intermediate tap 133 of the voltage divider 109.

The secondary 143 of the impulse transformer 139 is included in a circuit extending from the grid 145 of a control thyatron 147 through a grid resistor 149, the secondary 143 and a source of biasing potential 151 to the cathode 153 of

the control thyatron. The source of biasing potential 151 maintains a negative grid-cathode potential until current flows through the primary 137 of the impulse transformer. At that time, the potential of the secondary 143 causes the grid 145 to become positive with respect to the cathode 153 and renders the control thyatron 147 conductive. The control thyatron is preferably a Westinghouse KU-676 tube and is interposed between a source of direct-current potential 155 and the solenoid 157 for raising the diverting gate 15. The source of direct-current potential 155 may be taken from the rectifier 107. However, it is illustrated as an independent source because such is probably preferable in view of the load to be placed thereon. A voltage divider 159 is connected across the source of potential 155. When the control thyatron 147 is rendered conductive, current flows from the positive terminal of the divider 159 through a parallel circuit comprising the lower portion 161 of a variable resistor 165 and a capacitor 163 on one side and the upper portion 167 of the variable resistor 165 on the other side; and continues through the anode 169 and cathode 153 of the control thyatron 147, lead 171, the coil 173 of the solenoid 157 and lead 175 to the negative terminal of the divider 159. A variable resistor 177 and a capacitor 179 in series with each other are also connected between the cathode 153 of the control thyatron 147 and the negative terminal of the divider 159. It is apparent that, when the control thyatron 147 becomes conductive, the current flows simultaneously through the energizing coil 173 of the solenoid 157 and the capacitor 179. Thus, the capacitor 179 is charged at a constant rate from the instant the diverting gate 15 is raised. A bleed resistor 180 is connected across the resistor 177 and capacitor 179.

The capacitor 179 in circuit with the control thyatron 147 is also included in the control circuit of another thyatron 181, which may be called a stop tube and is preferably a Westinghouse KU-627 tube. The control circuit of the stop tube 181 extends from the grid 183 thereof through grid resistor 185, the capacitor 179 to the negative terminal of the voltage divider 159, and from an intermediate tap 187 of the divider through a resistor 189, a contactor 191 and energizing coil 193 of an auxiliary relay 195 to the cathode 197. The portion of the voltage divider in the control circuit of the stop tube 181 establishes a negative grid-cathode potential preventing the tube from becoming conductive. However, when the charge on the capacitor 179 in circuit with the control thyatron 147 attains a preselected value, it impresses a positive potential between the grid 183 and cathode 197 of the stop tube 181, rendering it conductive. Current then flows from the positive terminal of divider 159 through resistor 189, stop tube 181, coil 193, contactor 191, resistor 189 to the intermediate tap 187 of the divider.

While current is flowing through the control thyatron 147, the capacitor 163 connected across the variable resistor 165 is charged with its negative plate connected to the anode 169 of the control thyatron 147. The positive plate of the capacitor 163 is connected to the anode 199 of the stop tube 181. When the stop tube becomes conductive, the capacitor 163 is connected across the anode 169 and cathode 153 of the control thyatron 147 through the stop tube 181, the portion of the voltage divider between the intermediate tap 187 and the negative terminal and

the coil 173 of the solenoid 157. The charge on the capacitor 163 when the stop tube is rendered conductive, is sufficient to deionize the control thyatron 147 and stop the flow of current through coil 173. Shortly after the deionization of the control thyatron, the auxiliary relay 195 becomes sufficiently energized to open its contactor 181 and break the cathode circuit of the stop tube 181, rendering it non-conductive.

When the control relay 47 is deenergized in the manner previously described, one of its contactors 99 opens the anode circuit of the pentode 113, stopping the charging of the capacitor 119 in circuit therewith. At the same time another contactor 101 of the relay 47 closes to effect discharge of the capacitor 119 through a resistor 201 connected in parallel therewith. Deenergization of relay 47 also causes contactor 103 of the relay to close to effect discharge of the capacitor 179 in circuit with the control thyatron 147 through a resistor 203 in parallel therewith.

The operation of the apparatus commences when energy from the radiant source 25 passes through a pinhole to the photosensitive device 27. An impulse is then transmitted through the amplifying system 29 to the control unit 41, causing the control relay 47 to be energized. Upon energization of the control relay 47, charging of the capacitor 119 in circuit with the pentode is initiated. The capacitor 119 is charged at a rate dependent upon the speed of the moving material 3, and when the charge attains a predetermined value, the control thyatron 147 is rendered conductive as a result of the flow of current through the impulse transformer 139. The coil 173 of the solenoid 157 is energized when the control thyatron is rendered conductive and raises the diverting gate 15. At the same instant that the gate is raised, current flowing through the control thyatron begins to charge capacitor 179. After a predetermined period of time, the capacitor 179 in circuit with the control thyatron 147 attains a charge sufficient to render the stop tube 181 conductive. The stop tube 181 then permits the charged capacitor 163 to extinguish the control thyatron 147 and shortly thereafter the auxiliary relay 195 breaks the cathode circuit of the stop tube 181. When the control thyatron 147 is extinguished, the coil 173 of solenoid 157 is deenergized to permit the diverting gate 15 to return to its original position.

Although I have shown and described a certain specific embodiment of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. A control circuit for operating mechanism for designating heterogeneous portions of moving material comprising, charge-storing means, means connected to said storing means for charging said storing means at a rate dependent upon the speed of said material, means connected to said charging means and responsive to a heterogeneity in said material to initiate charging of said storing means by said charging means, actuating means for said designating mechanism, a capacitor, means connected to said actuating means and said capacitor for supplying energy thereto simultaneously, means responsive to the charge on said storing means connected to said energy supply means for initiating the supply

of energy from said supply means to said actuating means and said capacitor when the charge on said storing means attains a preselected magnitude, and means connected to said supply means and responsive to a charge of a predetermined magnitude on said capacitor for interrupting the supply of energy to said actuating means.

2. A control circuit for operating a mechanism for designating heterogeneous portions of moving material comprising, charge-storing means, means connected to said storing means for charging said storing means at a rate dependent upon the speed of said material, means connected to said charging means and responsive to a heterogeneity in said material to initiate charging of said storing means by said charging means, actuating means for said designating mechanism, an electric discharge valve of the arc-like type in circuit with said actuating means, means connected to said valve and actuating means for supplying energizing current to said actuating means under the control of said valve, control means connected to said valve and responsive to the charge on said storing means for rendering said valve conductive when said charge attains a preselected magnitude, and timing means connected to said valve for interrupting the conductivity of said valve a predetermined time after it is rendered conductive.

3. A control circuit for operating a mechanism for designating heterogeneous portions of moving material comprising, charge-storing means, means connected to said storing means for charging said storing means at a rate dependent upon the speed of said material, means connected to said charging means and responsive to a heterogeneity in said material to initiate charging of said storing means by said charging means, actuating means for said designating mechanism, a capacitor, an electric discharge valve of the arc-like type in circuit with said actuating means and said capacitor, means in circuit with said valve, actuating means and capacitor for supplying energy through said valve to energize said actuating means and charge said capacitor, control means connected to said valve and responsive to the charge on said storing means for rendering said valve conductive when the charge attains a preselected magnitude, and timing means connected to said valve and responsive to a charge of a preselected value on said capacitor for interrupting the conductivity of said valve.

4. A control circuit for operating a mechanism for designating heterogeneous portions of moving material comprising, charge-storing means, means connected to said storing means for charging said storing means at a rate dependent upon the speed of said material, means connected to said charging means and responsive to a heterogeneity in said material to initiate charging of said storing means by said charging means, actuating means for said designating mechanism, a capacitor, an electric discharge valve of the arc-like type in circuit with said actuating means and said capacitor, means connected to said valve for supplying energy through said valve to energize said actuating means and charge said capacitor, means connected to said valve and responsive to the charge on said storing means for rendering said valve conductive when the charge attains a preselected magnitude, timing means including a second electric discharge valve connected in circuit with said first valve for interrupting the conductivity of the latter, and control means connected to said second valve and responsive

to a charge of a preselected value on said capacitor for rendering said second valve conductive.

5. A control circuit for operating mechanism for designating heterogeneous portions of moving material comprising, an electric discharge device having a plurality of principal electrodes and being of the type through which the current flow is substantially independent of the potential across said principal electrodes, said device having a control electrode whereby the current flow may be varied, means adapted to function as a source of direct-current potential, charge-storing means, circuit-means connecting said storing means in circuit with said source through said principal electrodes including switch means for completing said connection in response to a heterogeneity in said material, means connected to said control electrodes for varying the flow of current through said device in accordance with the speed of said material, actuating means for said designating mechanism, an electric discharge valve of the arc-like type in circuit with said actuating means, means in circuit with said valve and actuating means for supplying energizing current to said actuating means under the control of said valve, and control means connected to said valve and responsive to the charge on said storing means for rendering said valve conductive when said charge attains a preselected magnitude.

6. A control circuit for operating mechanism for designating heterogeneous portions of moving material comprising, an electric discharge device having a plurality of principal electrodes and being of the type through which the current flow is substantially independent of the potential across said principal electrodes, said device having a control electrode whereby the current flow may be varied, means adapted to function as a source of direct-current potential, charge-storing means, circuit-means connecting said storing means in circuit with said source through said principal electrodes including switch means for completing said connection in response to a heterogeneity in said material, means connected to said control electrodes for varying the flow of current through said device in accordance with the speed of said material, actuating means for said designating mechanism, an electric discharge valve of the arc-like type in circuit with said actuating means, means in circuit with said valve and actuating means for supplying energizing current to said actuating means under the control of said valve, control means connected to said valve and responsive to the charge on said storing means for rendering said valve conductive when said charge attains a preselected magnitude, and timing means connected to said valve for interrupting the conductivity of said valve a predetermined time after it is rendered conductive.

7. A control circuit for operating mechanism for designating heterogeneous portions of moving material comprising, an electric discharge device having a plurality of principal electrodes and being of the type in which the current flow is substantially independent of the potential across said principal electrodes, said device having a control electrode whereby the current flow may be varied, means adapted to function as a source of direct-current potential, charge-storing means, circuit means connecting said storing means in circuit with said source through said principal electrodes including switch means for completing

said connection in response to a heterogeneity in said material, means connected to said control electrodes for varying the flow of current through said device in accordance with the speed of said material, actuating means for said designating mechanism, a capacitor, an electric discharge valve of the arc-like type in circuit with said actuating means and said capacitor, means connected to said valve for supplying energy through said valve to energize said actuating means and charge said capacitor, means connected to said valve and responsive to the charge on said storing means for rendering said valve conductive when the charge attains a preselected magnitude, and timing means connected to said valve and responsive to a capacitor potential of a preselected value for interrupting the conductivity of said valve.

8. A timing system comprising means adapted to function as a source of direct-current potential, a pair of capacitors and a load device in circuit with said source, an electric discharge valve of the arc-like type interposed in circuit with said source, load device and capacitors to control the flow of current from said source to energize said load and charge said capacitors, means connected to said valve to render it conductive, normally non-conductive means connecting one of said capacitors in a second circuit with said valve in which the potential of said one capacitor when charged is sufficient to render said valve non-conductive upon said non-conductive means becoming conductive, and means connected to said other capacitor and said normally non-conductive means to render the latter conductive when said other capacitor is charged to a preselected potential.

9. A timing system comprising means adapted to function as a source of direct-current potential, a pair of capacitors and a load device in circuit with said source, an electric discharge valve of the arc-like type interposed in circuit with said source, load device and capacitors to control the flow of current from said source to energize said load and charge said capacitors, means connected to said valve to render it conductive, circuit means including a second electric discharge valve of the arc-like type connecting one of said capacitors in a second circuit with said valve in which the potential of said one capacitor when charged is sufficient to render said valve non-conductive upon said second valve becoming conductive, and means connected to the other capacitor and said second valve to render the latter conductive when said other capacitor is charged to a preselected potential.

10. A control circuit for operating a mechanism for designating heterogeneous portions of moving material comprising, charge-storing means, means connected to said storing means for charging said storing means at a rate dependent upon the speed of said material, means connected to said charging means and responsive to a heterogeneity in said material to initiate charging of said storing means by said charging means, actuating means for said designating mechanism, a pair of capacitors, means adapted to function as a source of direct-current potential in circuit with said capacitors and said actuating means, an electric discharge valve of the arc-like type interposed in circuit with said source, capacitors and actuating means to control the flow of current from said source to energize said actuating means and charge said capacitors, means connected to said valve to render it conductive, normally non-

conductive means connecting one of said capacitors in a second circuit with said valve in which the potential of said one capacitor when charged is sufficient to render said valve non-conductive upon said non-conductive means becoming conductive, and means connected to said other capacitor and said normally non-conductive means to render the latter conductive when said other capacitor is charged to a preselected potential.

11. A timing system comprising a pair of electric discharge valves of the arc-like type, each having an anode, cathode and control electrode, a first resistor connected in circuit from the anode of one valve to the anode of the other valve, a first capacitor connected in parallel with said first resistor, means adapted to function as a source of direct-current potential having a positive terminal connected to an intermediate

point on said first resistor and a negative terminal, first circuit means including a second variable resistor and a second capacitor connected from the cathode of said one valve to said negative terminal, means connected to said control electrode and cathode of said one valve to render it conductive whereby current flows from said source through said one valve to charge said first and second capacitors, second circuit means connecting the control electrode of said other valve to a point in the circuit between the cathode of said one valve and said second capacitor, and third circuit means connecting the cathode of said other valve to a point in the circuit between said second capacitor and the positive terminal of said source.

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