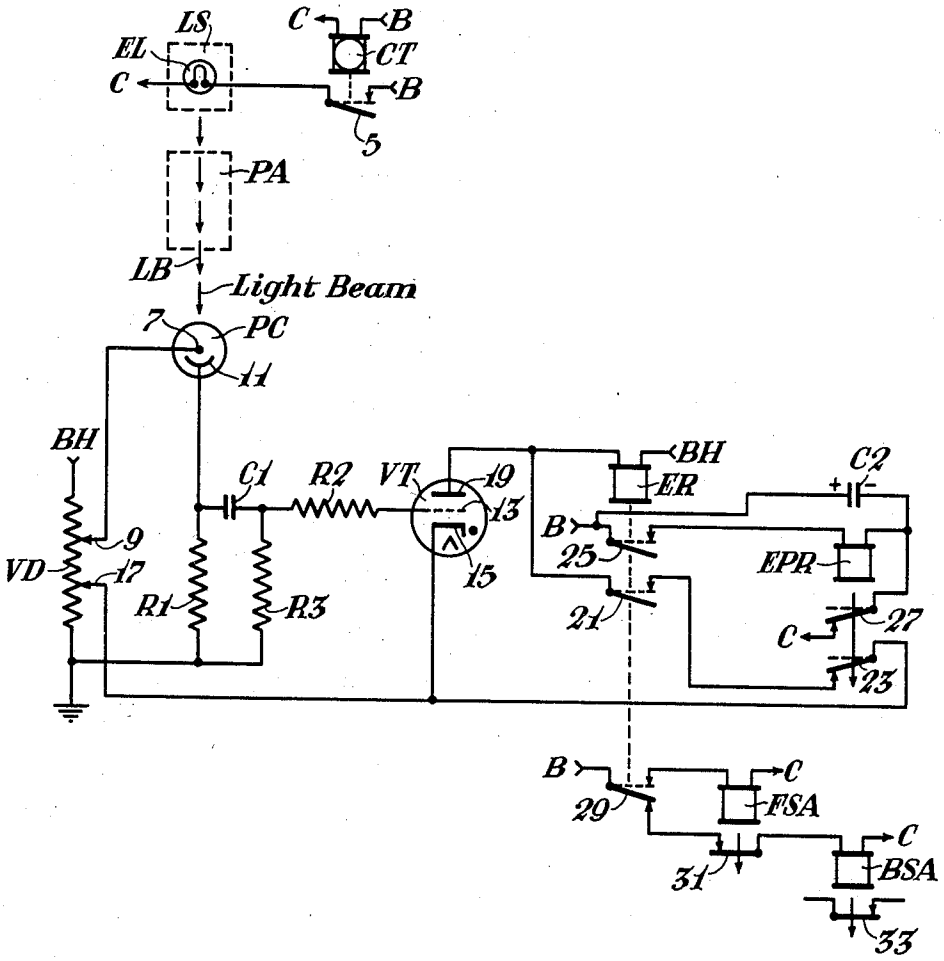
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ELECTRON TUBE CIRCUIT

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ELECTRON TUBE CIRCUITS

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My invention relates to electron tube circuits and particularly to electron tube circuits employing gas tubes of the grid-controlled type.

It is well known in the art that grid-controlled gas tubes have the inherent property of remaining conductive after being fired until the anode potential is reduced to a value below the deionizing voltage of the tube. That is, if sufficient potential is supplied to the anode of the tube, the tube will remain non-conductive as long as the control grid has a sufficient negative potential supplied thereto to prevent ionization from starting, but when the grid potential becomes less negative or becomes positive, the tube fires and the grid loses control. When alternating current is supplied to the anode of the tube, the tube can only fire on the alternate half-cycles in which the anode is positive with respect to the cathode, so that the tube is extinguished within one-half cycle after the grid is driven negative, and accordingly there is no difficulty in stopping the conduction of the tube in order that the grid may regain control.

However, if the anode is supplied with direct current energy, means must be provided to interrupt or materially reduce the current supplied to the anode circuit after the tube is fired in order for the grid to regain control of the tube. It has previously been proposed to provide a gas tube circuit for controlling a relay, in which short pulses of positive potential are supplied recurrently to the grid of a gas tube, the anode circuit of which is supplied with direct current, by providing a relay having its winding and one of its back contacts connected in series in the anode circuit so that when the tube fires on the reception of a pulse of voltage by its grid circuit, the relay will pick up and its back contact will interrupt the series anode circuit, whereby the tube is deionized and the relay released. When the contacts of the relay release, the series anode circuit is again established, but the tube is then deionized and under the control of its grid, so that the tube does not fire until another pulse drives the grid in a positive direction. Although this arrangement provides for stopping the conduction of the tube, it cannot be relied upon in the event of a fault. For example, if the anode and the cathode of the tube becomes short circuited, or if the control grid bias is lost so that the tube fires each time the anode circuit is closed, the relay in the anode circuit will recurrently pick up its contacts in a manner of "doorbell" operation, and the period of the operation might be the same as that of its normal operation, in which case the operation of the relay in the absence of the control voltage would be the same as if it were under control of the voltage normally supplied to the grid of the tube. This may be considered as an unsafe failure.

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The object of my invention is to provide an improved system of electron tube circuits for use with a gas-filled electron discharge device having a direct current anode supply, which system is adapted for use in a safety system embodying the closed circuit principle of operation.

More particularly, the object of my invention is to provide an improved system of electron tube circuits for operating a relay periodically in response to successive pulses of control energy supplied to a grid of a gas tube having its anode circuit supplied with direct current energy, which is so arranged as to prevent improper periodic operation of the relay in the event of a fault in the system.

Another object of my invention is the provision of an improved photocell detector system which is operable from a local direct current source, for the purpose of detecting the presence of an object within a protected area in a reliable manner.

Other objects of my invention and features of novelty therein will be apparent from the following description, taken in connection with the accompanying drawing.

In practicing my invention, I provide a gas tube having an anode, a cathode, and a control electrode, of the type in which the anode circuit is rendered conductive by the brief application of a positive potential to the control electrode, the anode circuit then remaining conductive until the anode voltage is reduced below a predetermined value. The control electrode is normally biased in a negative direction, to thereby render the tube normally non-conductive. The control electrode of the tube is recurrently supplied with pulses of control voltage having a value sufficient to overcome the bias and render the tube conductive. The anode circuit of the tube has in series therewith the winding of a control relay, and the parts are proportioned and arranged so that the relay picks up when the tube is rendered conductive. A shunting circuit is provided which includes a front contact of the control relay, by which the anode and cathode of the tube are connected together, or short-circuited, when the relay picks up. The shunting circuit also constitutes a stick circuit for the relay, so that each time the tube is rendered conductive by a control pulse the relay picks up and is held energized over its stick circuit which short-circuits the anode-cathode circuit of the tube to cause it to become deionized.

In order to restore the apparatus to its original condition when the control voltage ceases to be supplied, I provide a second relay which is arranged to interrupt the shunting circuit after a short time interval, so that the control relay will release, provided the anode-cathode circuit

in series with the relay has returned to its normal non-conducting state.

I shall describe one form of electron tube circuits embodying my invention and shall then point out the novel features thereof in claims.

The accompanying drawing shows a preferred embodiment of my invention as applied to an intrusion detection system employing an interrupted light beam and a photocell.

It is to be understood that my invention is not limited to use in photocell systems, but that it may be advantageously used in other systems involving the detection of recurrent electrical pulses of low energy.

Referring to the accompanying drawing, an intrusion detection system is shown which serves to detect the presence of an object within a protected area PA by the interruption of a light beam which is recurrently projected across the area PA to activate a photo-electric cell.

The light source LS includes an electric lamp EL which is recurrently supplied with energy from a low voltage direct current source, not shown, the positive and negative terminals of which are designated by the reference characters B and C, respectively. The supply of energy to the lamp EL is governed by a contact 5 of a code transmitter CT. Such code transmitters are well known in the railway signaling art, and it will suffice to point out that the code transmitter CT has its operating winding continuously connected to the low voltage source, and is constructed and arranged to recurrently open and close its contact 5 at some predetermined rate, say, for example, 180 times per minute.

Accordingly, the lamp EL of the light source LS is recurrently energized 180 times per minute and the flashes of light generated thereby are projected by a lens system, not shown, as a recurrently interrupted light beam across the protected area PA to photocell PC, as long as the space PA is not occupied.

The apparatus for detecting the recurrent flashes of light comprises the photocell PC, a gas tube VT, a first relay ER, a second relay EPR, and code-detecting means comprising two slow release relays FSA and BSA.

Energy for the operation of the photocell PC and gas tube VT is supplied from a high voltage direct current source, not shown, the positive terminal of which is designated by the reference characters BH, and the negative terminal of which is grounded.

The anode 7 of the photocell PC is supplied with positive direct current energy at a suitable value by an adjustable tap 9 of the voltage divider VD, which comprises a suitable resistance connected between terminal BH and ground. The cathode 11 of photocell PC is connected to ground through a load resistor R1, and the photocell PC is of the type in which the amount of conduction is dependent upon the intensity of the light falling upon the photo-sensitive portions of the cell.

The adjustable tap 9 of voltage divider VD provides a means for adjusting the sensitivity of the photocell PC, so that it may be adjusted to operate at maximum efficiency.

When the recurrently interrupted light beam LB strikes the photocell PC the conduction of the cell is increased, and the flow of current therethrough and through the load resistor R1 increases proportionally. The flow of current through the resistor R1 causes a voltage drop, which is supplied to the control electrode or grid 13 of gas tube VT, through a coupling condenser C1, and a protective resistor R2.

The cathode 15 of the gas tube VT is connected to an adjustable tap 17 of the voltage divider VD, while the grid 13 of gas tube VT is connected to ground through the resistor R2 and a grid bias resistor R3. Accordingly, it will be seen that the cathode 15 of gas tube VT is maintained at a slightly positive potential with respect to ground by the connection to voltage divider VD through the adjustable tap 17, while the grid 13 of the tube VT is connected to ground through the resistors R2 and R3. Thus the cathode 15 is slightly positive in potential with respect to the grid 13 or conversely, the grid 13 has a given negative bias with respect to the cathode 15 of the tube.

The anode 19 of tube VT is supplied with energy from the positive terminal BH of the high voltage direct current source through a winding of a relay ER, while as previously pointed out the cathode 15 is connected to ground through a portion of the voltage divider VD by the adjustable tap 17. The potential between the anode 19 and the cathode 15 of tube VT is such that it is sufficient to cause the tube to conduct when the grid 13 is driven in a positive direction. The apparatus is arranged and proportioned so that the value of negative grid bias supplied to the grid 13 of the tube is sufficient to prevent the tube from conducting, but when an impulse of control voltage is supplied to the grid 13 from the load resistor R1 as a result of the reception of light on the photocell PC, the grid 13 is driven sufficiently positive with respect to cathode 15 to allow the tube to conduct.

From the foregoing, it will be seen that when a positive pulse of energy is supplied to the control grid 13 of gas tube VT, as a result of the light beam striking the photocell PC, the tube VT will be rendered conductive, and the current which flows through the winding of relay ER will cause the relay to pick up its contacts. When contact 21 of relay ER picks up, it establishes a circuit for connecting the anode 19 of tube VT to the cathode 15, and which circuit is completed over a back contact 23 of relay EPR. As a result, the anode 19 and cathode 15 of tube VT are established at the same potential, and the tube will be deionized. The relay ER will remain picked up at this time however, since energy now flows through the winding of the relay ER, over front contact 21 of the relay, over back contact 23 of relay EPR, to the adjustable tap 17 on the voltage divider VD and to ground.

When contact 25 of relay ER picks up, it establishes a circuit for energizing the winding of relay EPR, which is traced from terminal B of the low voltage source, over front contact 25 of relay ER, through the winding of EPR, and over back contact 27 of relay EPR to terminal C. When relay EPR picks up, its back contact 27 interrupts the circuit for connecting its winding to terminal C, but the relay remains energized due to the flow of energy through its winding from condenser C2, condenser C2 having been charged from the low voltage source through back contact 27 of relay EPR and then connected across the winding of the relay EPR through front contact 25 of relay ER. Accordingly, it will be seen that when relay ER picks up, the relay EPR will pick up shortly thereafter, and will remain picked up for a short interval due to the charge on condenser C2.

When contact 23 of relay EPR picks up, it

interrupts the circuit previously traced for connecting the anode 19 and the cathode 15 of tube VT and also for maintaining the relay ER picked up by its stick circuit. The tube VT being now deionized so that conduction no longer takes place between the anode 19 and the cathode 15, the relay ER releases, and its contacts 21 and 25 open. When contact 25 of relay ER opens, it interrupts the circuit for supplying energy to the winding of relay EPR from the condenser C2 and relay EPR releases, thus restoring the equipment to its original condition.

It will be apparent that successive pulses of energy supplied to the grid of the gas tube VT will cause the operation described above to be repeated for each pulse.

The contacts of the code transmitter CT and the contacts of relays ER and EPR are shown by a downwardly inclined heavy line indicating one position of the movable contact and a horizontal dotted line indicating the other position of the movable contact, such a showing being well-known in the railway signaling art for designating contacts which may be recurrently operated between their two positions.

The recurrent operation of the contacts of relay ER is detected by code-detecting means including the slow release relays FSA and BSA. When relay ER picks up, its front contact 29 establishes an obvious circuit for supplying energy to the winding of relay FSA, and relay FSA picks up. When relay ER releases its contacts, a circuit is established for supplying energy to the winding of relay BSA which includes back contact 29 of relay ER and front contact 31 of relay FSA. Accordingly, energy will be supplied to relay FSA each time that contact 29 of relay ER is picked up, and energy will be supplied to the winding of relay BSA when contact 29 of relay ER is released, provided that contact 31 of relay FSA is picked up. Relays FSA and BSA are slow releasing and remain picked up when contact 29 is operated at a rate corresponding to the given rate of the impulses applied to gas tube VT. The contact 33 of relay BSA may be used to control various circuits, for example, signal control circuits for governing traffic movements into the protected area PA. It will be seen that if the recurrent operation of contact 29 ceases, the supply of energy to one or the other of the relays FSA and BSA will be cut off. As a result, the contact 33 of relay BSA will be released, thereby interrupting circuits controlled by that contact.

It will be apparent to those skilled in the art that my invention is not limited to the code detecting means shown and described, but that any suitable means for detecting the recurrent operation of a contact or contacts may be employed, such as, for example, the arrangement shown and described in Letters Patent of the United States No. 2,237,788, granted to Frank H. Nicholson et al.

Normally, with the protected area PA unoccupied, the recurrent flashes of light projected across the area by the light source LS to the photocell PC cause the recurrent operation of contact 29 of relay ER, with the result that relays FSA and BSA are picked up, and contact 33 of relay BSA maintains the circuit controlled thereby.

When the protected area PA is occupied, the light no longer is supplied to the photocell PC and as a result, relay ER releases and remains released, so that relays FSA and BSA release.

Contact 33 of relay BSA interrupts the circuits governed thereby, to indicate that the protected area PA is occupied.

When the protected area PA again is unoccupied, the light beam LB again strikes the photocell PC, with consequent operation of relay ER, and relays FSA and BSA are picked up, with contact 33 of relay BSA again establishing the circuit controlled thereby.

From the foregoing, it will be seen that my invention provides electron tube apparatus in which recurrent pulses of control energy supplied to a control electrode of the gas tube causes the tube to become conductive to thereby energize the relay. When the relay picks up, it establishes a circuit for causing the tube to be deionized, and also governs means for restoring the relay to its original condition. The recurrent operation of the contacts of the first relay governed by this tube, in this case relay ER, is detected by means of conventional code-detecting equipment.

As previously pointed out, it is essential that equipment of this type is arranged to insure that faulty operation cannot occur as a result of a failure of the tube or other derangement of the apparatus.

For example, if the tube VT has its anode 19 and cathode 15 short-circuited internally or otherwise or if a derangement otherwise occurs which causes the tube to continuously fire, it will be seen that the relay ER will be picked up and remain picked up, due to the continuous current through the tube. Since contact 25 of relay ER remains in its picked up position, the circuit for supplying energy to the winding of relay EPR is maintained, but back contact 27 of relay EPR causes the relay to interrupt its pick-up circuit each time that it picks up, so that after the release time determined by the charge of condenser C2, the relay EPR will release. Accordingly, it will be seen that the contacts of relay EPR will recurrently pick up and release in a "door-bell" fashion, and each time that contact 23 of relay EPR picks up it interrupts the circuit including front contact 21 of relay ER for quenching the tube. However, if the tube is continuously conducting or otherwise maintains a continuous path therethrough, the relay ER will remain steadily energized. When contact 29 of relay ER remains picked up, the supply of energy to the winding of relay FSA is continued, but the supply of energy to the winding of relay BSA is interruped by contact 29 of relay ER, so that after the release time of relay BSA has expired, its contact 33 will release and interrupt the circuits controlled thereby. Thus the apparatus will operate in the same manner as if the light beam LB were interrupted by an object occupying the protected area PA, and this type of failure is on the side of safety.

The relay EPR with its back contact 27 interposed in the circuit for supplying energy thereto from the source, has another function, namely, that of protecting the equipment against false operations caused by transient voltages supplied to the grid 13 of the tube VT.

It will be assumed that relay ER has picked up as a result of the supply of a pulse of control energy to the grid 13 of the tube VT, and that the tube VT has now been deionized and the relay ER is about to release. If a pulse of transient voltage is supplied to the grid 13 of the tube at this time, it will cause the tube to again become conductive and relay ER will continue to be picked up. However, relay EPR will release due to its

back contact 27 opening the circuit for supplying energy to the winding of the relay, and when back contact 23 of relay EPR releases, it establishes the circuit for shunting the plate and cathode of the tube VT, so that the tube is again deionized. Accordingly, with the circuit arranged in accordance with my invention, a transient voltage appearing at the grid 13 of gas tube VT just at a time that the relay ER is about to release its contacts would not lock up the relays and prevent further operation.

From the foregoing it will be seen that I have provided an electron tube circuit arranged for utilizing a gas type tube supplied with energy from a direct current source, and the arrangement is such that possible unsafe failures of the equipment are guarded against.

Although my invention is especially suited for use with electron tube circuits of the type described employing direct current energy, it is to be understood that the arrangement is equally suitable for use with alternating current energy.

Likewise, it is to be understood that the arrangement of relay control circuits is not limited to that shown on the drawings, and other arrangements of these circuits may be provided if desired.

Although I have herein shown and described only one form of apparatus embodying my invention, it is to be understood that various changes and modifications therein may be made within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a source of direct current, an electron discharge device supplied with current from said source, said device having an anode-cathode circuit which is rendered conductive by the application of a control voltage and which remains conductive when said voltage is reduced, as long as current is supplied thereto from said source, means for applying a control voltage to said device to render said circuit conductive, a first relay having its winding connected in series with said circuit to the terminals of said source, said relay assuming its energized position when said circuit becomes conductive, means including a front contact of said relay for short-circuiting said anode-cathode circuit to render said device non-conductive without releasing said relay, and means including a contact of a second relay controlled by said relay for removing said short circuit after said first relay has been picked up for a time interval long enough to enable said device to change from its conductive to its non-conductive state.

2. In combination, a source of direct current, an electron discharge device supplied with current from said source, said device having an anode-cathode circuit which is rendered conductive by the application of a control voltage and which remains conductive when said voltage is reduced, as long as current is supplied thereto from said source, means for applying a control voltage to said device to render said device conductive, a first relay having its winding connected in series with said circuit to the terminals of said source, said first relay assuming its energized position when said circuit becomes conductive, means including a front contact of said relay for short-circuiting said anode-cathode circuit without releasing said relay, and means including a contact of a second relay controlled by said first relay when energized for periodically

interrupting said short circuit, the interval between such interruptions being greater than the time required for said device to change from its conductive to its non-conductive state.

3. An electron tube circuit comprising an electron tube having an anode, a cathode and a control electrode, a source of direct current connected across said anode and said cathode and having in series therewith a winding of a first relay, said source and said tube being proportioned so that the voltage supplied to the tube from the source is sufficient to render said tube conductive, means for supplying biasing voltage to the control electrode of said tube to render the tube normally non-conductive, means for at times supplying recurrent voltage pulses to said control electrode of sufficient value to overcome said biasing voltage and thereby render the tube conductive, a second relay governed by a front contact of said first relay, and a circuit for shunting the anode and cathode of said tube and including a front contact of said first relay and a back contact of said second relay in series.

4. An electron tube circuit comprising an electron tube having an anode, a cathode, and a control electrode, a source of direct current connected across said anode and said cathode and having in series therewith a winding of a first relay, said source and said tube being proportioned so that the voltage supplied to the tube from the source is sufficient to render said tube conductive, means for supplying biasing voltage to the control electrode of said tube to render the tube normally non-conductive, a control voltage source for at times supplying voltage pulses to said control electrode, said pulses being of sufficient value to overcome said biasing voltage and thereby render the tube conductive, a slow release relay, a circuit for said slow release relay including a front contact of said first relay and its own back contact, and a circuit for shunting the anode and cathode of said tube including a front contact of said first relay and a back contact of said slow release relay.

5. In combination, a gas tube having an anode, a cathode and a control electrode, a source of direct current connected across said anode and said cathode and having in series therewith a winding of a first relay, said source and said tube being proportioned so that the voltage supplied to the tube from the source is sufficient to render said tube conductive, means for supplying biasing voltage to the control electrode of said tube to render the tube normally non-conductive, a control voltage source for at times supplying voltage to said control electrode of value sufficient to overcome said biasing voltage and thereby render the tube conductive, a second relay, a circuit for said second relay including its own back contact and a front contact of said first relay, and a circuit for shunting the anode and cathode of said tube including a front contact of said first relay and a back contact of said second relay.

6. In combination, an electron tube of the gas filled type having an anode, a cathode, and a control electrode, a source of direct current for supplying a positive voltage to said anode, means for supplying a biasing voltage to the control electrode of said tube, a source of control voltage for supplying recurrent pulses to the control electrode of said tube, said tube being rendered conductive each time a pulse is supplied to said control electrode, a first relay connected in series with said direct current source and said anode, whereby said relay is energized when said tube is con-

ductive, means for rendering said tube non-conductive each time said first relay becomes energized comprising a second relay governed by a front contact of said first relay and a circuit for connecting the anode to the cathode of said tube which includes a front contact of said first relay and a back contact of said second relay, and means for distinctively indicating the recurrent operation of said first relay.

7. An electron tube circuit comprising an electron tube of the gas filled type having an anode, a cathode and a control electrode, a source of direct current anode voltage sufficient to render said tube conductive, means for supplying a biasing voltage to said control electrode to prevent said tube from conducting, a source of recurrent pulses of control voltage having a value sufficient to overcome said biasing voltage and thereby render said tube conductive, means for supplying said pulses recurrently to said control electrode, a first relay having its winding connected in series with said anode and said direct current source, said first relay assuming its energized position when said tube is rendered conducting, a second relay, a circuit for said second relay including a front contact of said first relay and its own back contact, a circuit for connecting the anode and cathode of said tube together including a front contact of said first relay and a back contact of said second relay, a slow release relay controlled over a front contact of said first relay, a detector relay, a circuit for said detector relay including a back contact of said first relay and a front contact of said slow release relay whereby said detector relay is maintained energized only in response to the recurrent operation of said first relay.

8. An electron tube circuit comprising an electron tube having an anode electrode, a cathode electrode, and a control electrode, a source of energy connected across said anode and said cathode and having in series therewith a winding of a first relay, said first relay being arranged and proportioned so that its contacts are operated from a first to a second position when said tube is rendered conductive, said source and said tube being proportioned so that the voltage supplied to the tube from the source is sufficient to render said tube conductive, means for supplying biasing voltage to the control electrode of said tube to render the tube normally non-conductive, means for at times supplying recurrent voltage pulses to said control electrode of sufficient value to overcome said biasing voltage and thereby render the tube conductive, a second relay governed by a second position contact of said first relay and having contacts operated from a first to a second position when energy is supplied to the winding of the relay, a circuit including a second position contact of said first relay and a first position contact of said second relay for connecting together two of said electrodes of said tube to thereby render the tube non-conducting, and a stick circuit including a second position contact of said first relay and a contact of said second relay closed in its first position for retaining said first relay in its second position for a short time interval after said tube is rendered non-conducting.

9. An electron tube circuit comprising an electron tube having an anode electrode, a cathode electrode, and a control electrode, a source of

energy connected across said anode and said cathode and having in series therewith a winding of a first relay, said first relay being arranged and proportioned so that its contacts are operated from a first to a second position when said tube is rendered conductive, said source and said tube being proportioned so that the voltage supplied to the tube from the source is sufficient to render said tube conductive, means for supplying biasing voltage to the control electrode of said tube to render the tube normally non-conductive, means for at times supplying recurrent voltage pulses to said control electrode of sufficient value to overcome said biasing voltage and thereby render the tube conductive, a second relay governed by a second position contact of said first relay, a shunting circuit including a contact of said first relay closed in its second position for rendering said tube non-conductive, said shunting circuit including a contact of said second relay for opening said shunting circuit, and a stick circuit for maintaining said first relay in its second position for a short time interval after said tube stops conducting, said stick circuit including a second position contact of said first relay and a contact of said second relay.

10. An electron tube circuit comprising an electron tube having an anode electrode, a cathode electrode, and a control electrode, a source of energy connected across said anode and said cathode and having in series therewith a winding of a first relay, said first relay being arranged and proportioned so that its contacts are operated from a first to a second position when said tube is rendered conductive, said source and said tube being proportioned so that the voltage supplied to the tube from the source is sufficient to render said tube conductive, means for supplying biasing voltage to the control electrode of said tube to render the tube normally non-conductive, means for at times supplying recurrent voltage pulses to said control electrode of sufficient value to overcome said biasing voltage and thereby render the tube conductive, a second relay governed by a second position contact of said first relay, a first circuit including a contact of said first relay for stopping the conduction of said tube, a stick circuit for maintaining said first relay in its second position, and means including contacts of said second relay for opening said first circuit and said stick circuit after a short time interval following the operation of said first relay to its second position.

11. In combination, a gas tube having an anode, a cathode and a control electrode, a source of direct current, a relay, an anode-cathode circuit including in series said source, the anode-cathode tube space of said tube and a winding of said relay, said relay being energized and picked up in response to the current flowing in the anode-cathode circuit when said tube is ionized, means including a source of control voltage connected to said control electrode to at times apply a voltage that ionizes said tube, and a circuit path including a contact of said relay closed when said relay is energized to short-circuit the anode and cathode of said tube to enable the tube to change from its ionized to its deionized condition subsequent to the application of said control voltage.

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No references cited.