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ELECTRON TUBE CIRCUITS

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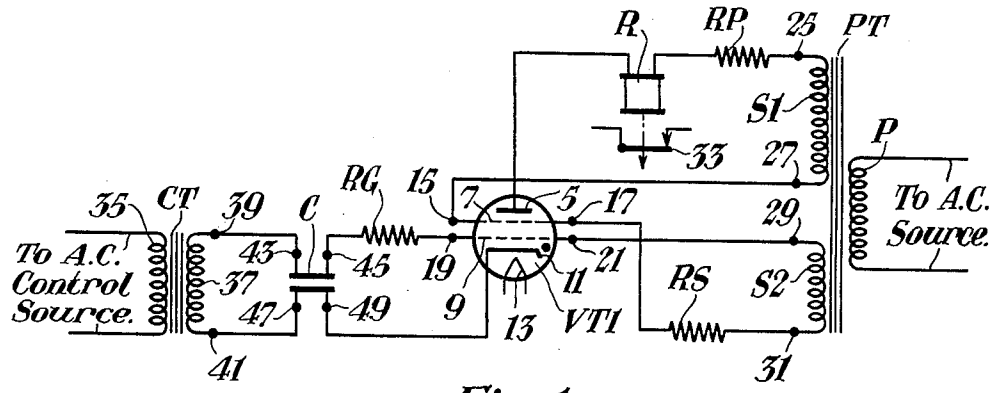


Fig. 1.

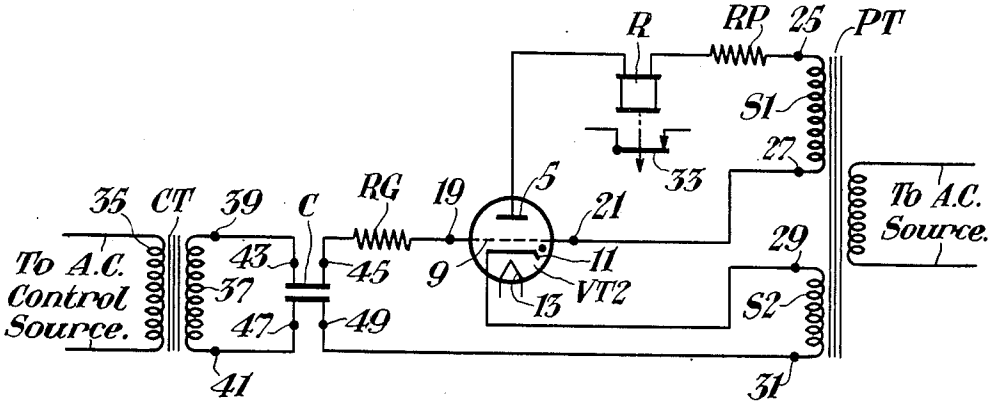


Fig. 2.

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ELECTRON TUBE CIRCUITS

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1 Claim. (Cl. 315—170)

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My invention relates to electron tube circuits and particularly to electron tube circuits arranged to provide safe operation of the circuits and apparatus associated therewith.

For the purposes of this disclosure, it is to be understood that the term "electron tube" shall mean an electron discharge device comprising an enclosure containing therein two or more electrodes and being either highly evacuated or filled with gas at a low pressure, while the term "gas tube" shall specifically mean an electron tube filled with gas at a low pressure.

In certain applications of electron tube circuits such as, for example, relay control circuits for railway signaling systems, it is essential to insure that the relay governed by the electron tube will pick up when and only when a control voltage of particular character is supplied to the input circuit of the electron tube which has the relay winding connected to its anode circuit. A bias voltage is generally provided for preselecting the operating characteristics of the electron tube circuits, and it is necessary to provide means for checking the continuity of the elements by which the bias voltage is supplied to the tube.

Additionally, it has been found that under certain conditions electron tubes of the gas type will continue to conduct, having once been rendered conductive, if the input circuit to the grid and cathode of the tube is interrupted in such manner that the grid is coupled, capacitively or otherwise, to a possible source of stray voltage.

Another possible cause of improper operation of gas tube circuits is that of false firing or conduction of the tube due to leakage of current in the tube base or wiring between the anode and control grid when the normal input circuit between the control grid and cathode of the tube is interrupted.

Accordingly, it is an object of my invention to provide novel and improved electron tube circuits arranged for safe operation.

Another object of my invention is to provide electron tube circuits incorporating novel means for checking the supply of bias voltage to an electron tube.

A further object of my invention is to provide electron tube circuits incorporating novel means for preventing the conduction of the tube by leakage current if the control circuit therefor becomes disconnected.

Another object of my invention is to provide novel and improved electron tube circuits arranged to prevent the conduction of the tube by stray voltages supplied to the grid of the tube if the grid-cathode circuit is interrupted.

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

In practicing my invention I provide a circuit arrangement which includes one or more of the control electrodes in a multi-element electron tube and the source of bias voltage in series with the anode circuit of the tube, and also includes the control circuit for the tube in series therewith, so that the several circuits form a series arrangement, whereby an interruption of any part of the complete circuit prevents the flow of current in the anode circuit and thereby prevents the operation of the relay in the anode circuit of the tube. Additionally, I provide a four-terminal condenser connected in shunt across the input circuit in order to shunt stray voltages while the plates of the condenser are connected as series elements in the input portion of the circuit so that an open connection to the condenser results in a safe failure of the apparatus.

I shall describe two forms of apparatus embodying my invention and shall then point out the novel features thereof in the claim.

In the accompanying drawings,

Fig. 1 is a diagrammatic view showing one form of electron tube circuits embodying my invention when employing a four-element electron tube, and

Fig. 2 is a diagrammatic view showing a modification of the arrangement of Fig. 1, which employs a three-element electron tube.

Similar reference characters refer to similar parts in each of the two views.

Referring to Fig. 1, the reference character VT1 designates a four-element indirectly heated gas tetrode of the "thyratron" type, having an anode 5, a shield grid 7, a control grid 9, a cathode 11 and a heater 13. The shield grid 7 of tube VT1 is provided with two terminals 15 and 17, and the control grid 9 is also provided with two terminals 19 and 21, and these grids are arranged so that the grid structure forms a series circuit between the terminals associated with each of the grids. Thus a circuit connected to the terminals of these grids includes the grid structures and grid connections in series so that any break in the grids or their connections within the tube will interrupt the circuit. The heater 13 of tube VT1 is supplied with energy from a suitable source, not shown.

Power is supplied to the anode 5 of the tube VT1 from a suitable source, here shown as a secondary winding S1 having terminals 25 and 27 of a transformer PT, which has its primary

winding P connected to a suitable source of alternating current, not shown. A second secondary winding S2 provided with terminals 29 and 31, provides a suitable source of bias voltage for the shield grid 7 of the tube VT1. The winding of a relay R and a limiting resistor RP are connected in series between terminal 25 of secondary winding S1 and the anode 5 of tube VT1, and terminal 27 of secondary winding S1 is connected to terminal 15 of the shield grid 7. Relay R is of the type having contacts which are slow to release, in order that the contacts of the relay will remain picked up during the alternate half cycles of the alternating current supplied to the anode circuit of the tube for which the tube is non-conductive, and the slow-releasing feature is preferably secured by the use of a copper ferrule or sleeve on the core of the relay, which acts as a short-circuited single turn winding, this type of relay structure reducing the value of induced voltage generated by the self-induction of the winding of the relay when the current which flows therethrough is cut off. A contact 33 of relay R governs a control circuit, not shown.

Terminal 17 of shield grid 7 of the tube VT1 is connected to terminal 31 of the secondary winding S2 through a current limiting resistor RS, and terminal 29 of the secondary winding S2 is connected to terminal 21 of the control grid 9 of tube VT1.

The tbe VT1 is governed by a source of alternating current control energy, not shown, which energy is at times supplied to the primary winding 35 of a control transformer CT. The secondary winding 37 of control transformer CT is provided with terminals 39 and 41, and terminal 39 is connected to terminal 19 of the control grid 9 of tube VT1 by a circuit which includes in series a grid resistor RG and one plate of a four-terminal condenser C, this one plate having terminals 43 and 45. Terminal 41 of the secondary winding of transformer CT is connected to the cathode 11 of tube VT1 by a circuit including in series the other plate of condenser C, and which other plate is provided with terminals 47 and 49.

These several circuits of tube VT1 are connected in series to form an anode circuit which may be traced from terminal 25 of secondary winding S1 of transformer PT through resistor RP, through the winding of relay R to the anode 5 of tube VT1, through the tube space of tube VT1 to the cathode 11, through one plate of condenser C by way of terminals 49 and 47 to the terminal 41 of secondary winding 37 of transformer CT, from the other terminal 39 of secondary winding 37 of transformer CT through the other plate of condenser C by way of terminals 43 and 45, through the limiting resistor RG, through control grid 9 of tube VT1 by way of terminals 19 and 21 to the terminal 29 of the secondary winding S2 of transformer PT, from the other terminal 31 of secondary winding S2 through the limiting resistor RS, and through the shield grid 7 of tube VT1 by way of terminals 17 and 15 to the terminal 27 of secondary winding S1 of transformer PT. Accordingly, it will be seen that during the half cycles of alternating current energy supplied by the secondary winding S1, in which the terminal 25 is positive in polarity with respect to the terminal 27, if the bias voltage and the control voltage are suitable to cause the tube to conduct, current flows through the circuit traced above to energize relay R and causes the contact 33 of relay R to be picked up. As previously explained the relay R is slow in releasing, so that during the alternate half cycles in which the tube VT1 is nonconductive, the relay R will continue to hold its front contact 33 closed.

The conducting condition of tube VT1 is predetermined by the proper arrangement and proportioning of the bias voltage supplied to the shield grid 7 of tube VT1 from the secondary winding S2 of transformer PT. The bias voltage supplied to the shield grid 7 from the transformer PT is supplied thereto by a circuit one side of which may be traced from terminal 31 of secondary winding S2 through the limiting resistor RS to terminal 17 of the shield grid 7, and the other side of which circuit may be traced from the terminal 29 of secondary S2 to the cathode 11 of tube VT1 through the control grid 9, by way of terminals 21 and 19, the limiting resistor RG, one plate of condenser C by way of terminals 45 and 43, the secondary winding 37 of control transformer CT by way of terminals 39 and 41, and to the cathode 11 of tube VT1 through the other plate of condenser C by way of terminals 47 and 49. The windings S1 and S2 of transformer CT are arranged and connected so that the energy supplied to the anode of the tube and the bias voltage supplied to the shield grid of the tube are of opposite polarity. That is, when the instantaneous polarity of the alternating current energy supplied from the secondary windings S1 and S2 is such that the anode 5 of tube VT1 is positive with respect to the cathode 11, the biasing voltage supplied from the secondary winding S2 is such that the shield 7 is negative with respect to the cathode 11.

From the foregoing, it will be seen that the circuit network shown in Fig. 1 is arranged and constructed so that the circuit by which energy is supplied to the winding of relay R includes in series therewith all other elements of the circuit network, so that if a break develops in any portion of the circuit network, the supply of energy to the relay R will be interrupted, and its contact 33 will release, opening the circuit which is controlled thereby. The secondary windings S1 and S2 are proportioned and arranged so that normally, that is, when no control voltage is supplied to the control grid 9, the bias voltage supplied to the shield grid 7 of tube VT1 is sufficient to prevent the tube from firing during the alternate half cycles in which the anode 5 is positive with respect to the cathode 11.

It will now be assumed that a control voltage of proper phase and voltage value is supplied to the primary winding 35 of control transformer CT. Accordingly, a potential is established between the control grid 9 and the cathode 11 of tube VT1, since these elements of the tube are connected to the secondary winding 37 of control transformer CT by the circuit including the plates of condenser C, as previously described in connection with tracing the anode circuit. If the polarity of the alternating current control voltage supplied at this time is such that the control grid 9 is positive with respect to cathode 11 of tube VT1 at the time during which the anode 5 is also positive with respect to the cathode 11, and if the control voltage supplied to the control grid 9 of tube VT1 is of sufficient value to overcome the biasing voltage applied to the shield grid 7, the tube will conduct and energy will be supplied to the winding of relay R and its contact 33 will be picked up. As previously explained, during the alternate half cycles in which the

polarity of the voltage supplied to the anode 5 of tube VT1 is negative, so that the tube cannot conduct, the relay R will remain picked up due to its slow releasing characteristics. Thus, it will be seen that when control voltage of the proper value and phase relationship to the voltage is supplied to the anode 5 and the screen grid 7 of tube VT1, the relay R will be energized and its contact 33 will be picked up and remain picked up as long as the alternating current control voltage is supplied to the primary winding 35 of transformer CT.

As previously explained, the circuit for supplying energy to the winding of relay R includes the shield grid 7 and the control grid 9, the secondary winding S2, the secondary winding 37 of transformer CT and the plates of condenser C in a series circuit. Accordingly, if any portion of the circuit is broken, whether the grids become open inside the tube, or if the wire connection between the various elements becomes broken or disconnected, it will be apparent that the supply of energy to the winding of relay R will be interrupted, so that contact 33 of relay R will release after a time interval, and will remain released. Also, if the supply of bias voltage is interrupted in such manner that the tube might possibly conduct without the presence of a positive potential on the control grid 9, the anode circuit will be open, and relay R will be released. Likewise if any of the elements in the control portion of the circuit including the secondary winding 37 of transformer CT, the condenser C, and their connections to the control grid 9 and cathode 11 become open, the anode circuit including relay R will be interrupted, so that relay R will release.

From the foregoing, it will be seen that vacuum tube circuits arranged as shown in Fig. 1 will provide safe operation, and the derangement of any portion of the circuits will be promptly detected by the failure of the relay R to pick up, which in itself is a failure on the side of safety.

In the types of electron tube circuits previously proposed, if the connection between the source of control voltage and the cathode of the tube became open while the connection between the control source and the control grid remained intact, stray high-frequency voltages supplied to the grid of the tube by capacitive coupling effect were in some cases sufficient to cause the tube to become conductive. However, in a circuit arranged as shown in Fig. 1 and embodying my invention, I provide condenser C, which is proportioned and arranged to effectively shunt any such stray voltages which are present in the input circuit including the secondary winding 37 of transformer CT. It is contemplated that the condenser C will be selected so that it will have sufficient reactance at the frequency of the control voltage to prevent it from shunting the control energy enough to prevent the tube VT1 from being properly controlled thereby, but that the condenser C will have sufficient capacity to effectively shunt small stray high-frequency voltages which may appear across the secondary winding 37, due to extraneous voltages supplied from the alternating current control source. In order that the presence of condenser C may be checked at all times to insure that stray voltages supplied from the secondary winding 37 will be shunted, the plates of the condenser are each provided with two terminals, and the anode circuit is carried through each plate of the condenser as previously traced. Accordingly, it will be seen that if either plate of condenser C becomes open or if

the connections thereto are open or broken, the anode circuit will be interrupted, so that relay R will release if picked up or remain released if not picked up.

Since the circuit for supplying the alternating current control voltage to the control grid 9 of tube VT1 is a portion of the series anode circuit previously described, it will be apparent that should the connection to the control grid 9 become broken or disconnected, the anode circuit for the tube will be interrupted so that relay R will be released if already picked up or will fail to pick up. Accordingly, no possibility of false firing of the tube due to leakage between the anode 5 or its connections and the control grid 9 or its connections can occur since any such leakage current will be shunted by the relatively low impedance winding 37 and capacity C, as long as the circuit is intact, so that such leakage current will not develop appreciable voltage between the control grid and cathode sufficient to cause the tube to fire improperly. If the grid circuit connection to capacity C and winding 37 is open, the anode circuit will also be interrupted at the same point as previously pointed out.

The grid protective or limiting resistor RG, which is included primarily to limit the flow of current between the grid and cathode when the control grid is at positive potential, may alternatively be connected between the control source and capacitor C, that is, between terminals 39 and 43. The capacitor C would thus be even more effective in shunting stray high-frequency voltages from the control grid.

In vacuum tube circuits of the type described it has been the practice to provide a relay which is rendered slow in releasing its contacts by the connection of a condenser, resistor, or a snubbing rectifier across the winding of the relay. Such an arrangement may result in false operation of the relay, since if the snubbing circuit becomes disconnected, the inductive voltage provided by the self-induction of the relay winding when the anode circuit is interrupted may be sufficient to cause the tube to remain in a conductive condition and thus cause the relay to remain picked up. Accordingly, I prefer to provide a relay of the type which is rendered slow in releasing by the provision of a copper ferrule or sleeve surrounding the core structure of the relay, since the possibility of a short or open circuit in this single-turn copper winding is extremely remote.

Referring to Fig. 2, there is shown a modification for the arrangement shown in Fig. 1, in which the tube VT2 is a three-element indirectly heated gas triode. The parts are arranged and constructed in the same manner as those shown in Fig. 1, with the exception that the biasing voltage supplied by the secondary winding S2 of transformer CT is utilized to provide a negative potential on the control grid 9 of the tube VT2, so that during the time that the anode voltage is positive wtih respect to the cathode, the biasing voltage supplied to the control grid 9 will prevent the tube from conducting.

The anode circuit for the tube VT2 including the winding of relay R may be traced from terminal 25 of secondary winding S1 of transformer PT, through the resistor RP and the winding of relay R to the anode 5 of tube VT2, through the tube space to the cathode 11 of the tube, to terminal 29 of the secondary winding S2 of transformer PT, from terminal 31 of secondary winding S2 through one plate of condenser C by way of

terminals 49 and 47, through the secondary winding 37 of the control transformer CT by way of terminals 41 and 39, through the other plate of condenser C by way of terminals 43 and 45 to the resistor RG, and through the control grid 9 of tube VT2 by way of terminals 19 and 21 to terminal 27 of the secondary winding S1 of transformer PT. As explained in connection with Fig. 1, the anode circuit includes all of the control elements in a series arrangement, so that an interruption in any portion of the circuit will interrupt the supply of energy to the winding of relay R. The secondary winding S2 of transformer PT is arranged and constructed to provide a biasing voltage to the control grid 9 of tube VT2 which is sufficient to prevent the tube from becoming conductive during the alternate half cycles in which the anode 5 of tube VT2 is positive with respect to the cathode 11. Accordingly, during the time in which there is no control energy supplied to the primary winding 35 of the control transformer CT, the tube remains non-conductive and the contact 33 of relay R is released.

If an alternating current control voltage is now applied to the primary winding 35 of the control transformer CT, the alternating current voltage induced in the secondary winding 37 of transformer CT will be supplied to the grid 9 of tube VT2, and if this voltage is of sufficient value to overcome the biasing voltage supplied from the secondary winding S2 of transformer CT, the tube will conduct on alternate half cycles, and the relay R will pick up its contact 33. As explained in connection with Fig. 1, the relay R is slow in releasing so that contact 33 remains picked up during the alternate half cycles in which the tube is not conducting.

As explained in connection with Fig. 1, the anode circuit of the arangement shown in Fig. 2 is a series arrangement in which all of the control elements and the sources of energy for the operation of the tube are checked. Accordingly, if one of the connections is broken or the series circuit is otherwise interrupted, the supply of energy to relay R will be interrupted and after a short time interval its contact 33 will release. As previously explained, the release of contact 33 of relay R is considered a safe type of failure.

From the foregoing, it will be seen that my invention provides electron tube circuits in which all of the elements are checked by a series circuit arrangement, and which series circuit includes the relay controlled by the electron tube, so that any failure of a portion of the circuit will result in the relay being deenergized.

Although the circuits have been shown and described as employing gas type tubes of the "thyratron" type, it is to be understood that my invention is not limited to this type of tube, and any suitable type of electron tube may be used.

Although I have herein shown and described only two forms of electron tube circuits embodying my invention, it is to be understood that various changes and modifications may be made therein within the scope of the appended claim without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

In combination, an electron tube of the gas type having an anode, a cathode and a control electrode; said tube provided with two terminals between which said control electrode forms a series path, an anode voltage source, a bias voltage source, a condenser, the plates of which are provided each with two terminals and between which two terminals the respective plate forms a series path, a control winding to which a control voltage is at times applied, and a circuit including in series said anode voltage source, said anode and tube space to said cathode, said bias voltage source, one plate and its two terminals of said condenser, said control winding, the other plate and its two terminals of said condenser, and said control electrode with its two terminals; whereby false firing of said tube due to a broken circuit element of said bias voltage source or of said control winding or of said condenser is avoided.

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