Feb. 24, 1942. A. P. MONTGOMERY 2,273,978

CONTROL CIRCUIT FOR GAS TRIODES

Filed March 31, 1939

Fig. 1.

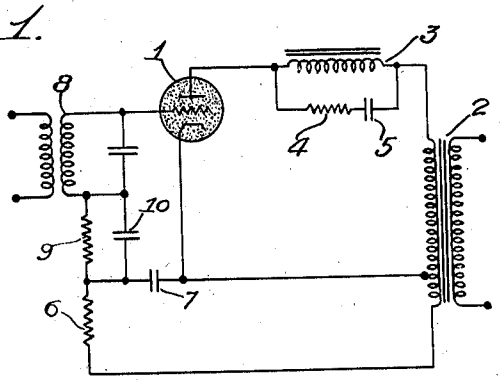


Fig. 2.

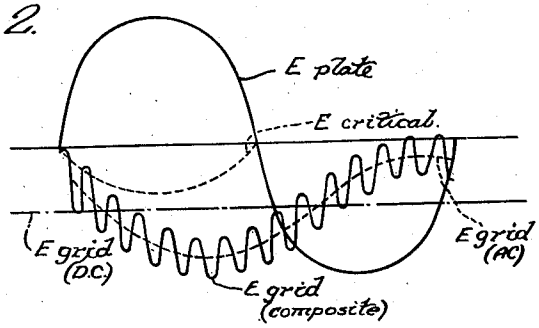
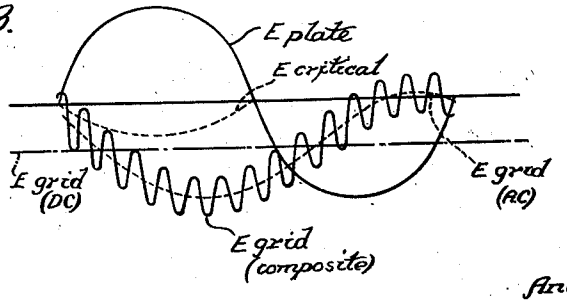


Fig. 3.



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Patented Feb. 24, 1942

2,273,978

UNITED STATES PATENT OFFICE

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CONTROL CIRCUIT FOR GAS TRIODES

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Application March 31, 1939, Serial No. 265,328
In Great Britain August 26, 1938

13 Claims. (Cl. 250—27)

This invention relates to control circuits for grid-controlled gas triodes or "thyratrons." The invention is particularly directed to those circuits wherein the gas triode is employed in the control of electromechanical relays and the like and wherein alternating current power is supplied to the plate circuit of the gas triode.

One object of the invention is to provide circuits for such a triode which result in a more reliable and positive control than has heretofore been possible.

Another object of the invention is to provide a means for maintaining a continuous current in the load circuits of gas triodes supplied only with alternating current plate power.

A further object of the invention is to provide a reliable control circuit for gas triodes wherein suitable alternating current voltages are applied to both grid and plate in such phase and magnitude that the gas triode is maintained in a non-ionized condition, but wherein the triode may be fired by the application to the input circuit of a relatively feeble radio frequency signal.

Still another object of the invention is to provide a gas triode control circuit wherein the signal applied to the input circuit of the triode comprises a low frequency alternating current voltage as well as a direct current component on which may be superimposed a high or radio frequency control-signal, said direct current component being a function of the state of conductivity of the gas triode, as well as of the presence or absence of the radio frequency control signal.

Accordingly, the invention provides in a control circuit for gas triodes and the like, a gas triode having an input electrode and an output electrode, means for applying alternating current voltages of predetermined phases and magnitudes to said electrodes, a load device connected to said output electrode, means for applying a bias voltage to said input electrode, means for applying a radio frequency signal to said input electrode, the space path of said triode being rendered conducting in the presence of said signal for positive alternations only of the output electrode supply voltage, and means associated with said load device for maintaining a flow of current therein during the negative alternations of said output electrode supply voltage.

In the accompanying drawing:

Fig. 1 illustrates a specific embodiment of the invention;

Fig. 2 is an illustrative diagram of several voltages present in the circuit; and

Fig. 3 is a diagram representing the voltages corresponding to those of Fig. 2 under different conditions.

In Fig. 1, a transformer **2** whose right-hand terminals may be connected to any suitable alternating current power source, is employed to supply plate voltage to the plate of the gas triode **1** by way of the load **3**, and grid voltage to grid of the triode by way of the resistors **6** and **9** and the secondary of the transformer **8**. The cathode is shown connected to a tapped point on the transformer. Separate transformers may, of course, be employed to supply the grid and plate voltages if desired. The relative phase of the two voltages may be fixed by means of a suitable phase shifting network which may comprise resistor **6** and a condenser **7**. The grid electrode is supplied with a self-bias voltage by means of a resistance-capacity network **9—10**, the specific operation of which will be described hereinafter.

Associated with the load impedance **3** is an energy storing element such as the condenser **5** and, if desired, a resistor **4**. The time constant of this circuit will preferably be greater than the period of the plate voltage so as to insure a more or less continuous flow of current through the load **3**, as will be explained hereinafter. The resistor **4**, in addition to having an effect on the time constant of the circuit **3—4—5**, may further be employed to limit the peak current through the triode, since in some instances the condenser **5** may have a comparatively high capacity.

A suitable signal may be applied to the input circuit of the gas triode by way of the transformer **8** which may be tuned if desired. The input terminals of the transformer **8** may be supplied with such a signal from any suitable source such as a signal receiving system.

Thus, it is seen that the grid-cathode circuit of the gas triode may be supplied simultaneously with three separate voltages, namely, an alternating current component from the transformer **2**, a direct current component due to rectified grid current, and a signal component from the transformer **8**.

All of these voltages are shown in Figs. 2 and 3 from which the operation of the device may be understood. In these figures are shown the alternating current wave of voltage applied to the gas triode plate, the critical grid voltage below which the triode will not fire, the alternating current grid voltage which is applied to the grid by way of the phase shifting network **6—7**, the direct current grid voltage, and the composite grid voltage which is the sum of the grid voltages here mentioned and the radio frequency signal

voltage supplied by the transformer 8. Since the characteristics of gas triodes or "thyratrons" are well known to those skilled in the art, it is believed to be unnecessary to review their theory.

Referring first to Fig. 2, it may be seen that when no radio frequency signal is present, the grid voltage will be more negative than the critical voltage necessary to prevent ionization of the gas in the triode 1. Consequently, there will be no current flow in the plate circuit of the triode. However, when a radio frequency signal is present, as shown, the grid will become momentarily less negative than this critical voltage, so that the gas in the tube may ionize and a current flow through the load 3 for the duration of the positive alternation of the plate voltage wave. This current will also charge the condenser 5. Hence, during the negative alternation of the plate voltage wave when no space current flows through the triode, the charge on the condenser will leak off through the load impedance 3 so as to maintain a continuous current therein. It is, of course, understood that upon the cessation of the radio frequency signal, the gas triode will cease to conduct, and will remain in this state until the radio frequency signal again appears as hereinbefore described.

The phase-shifting network 6—7 is preferably adjusted to provide a phase difference between the alternating current grid and plate voltages of such an order that firing of the gas triode in the presence of a radio frequency signal will occur at the beginning of the alternating current plate cycle rather than at a later time. This preferred condition is shown both in Figs. 2 and 3. If firing occurs too late in the cycle, the available load current may be seriously limited.

Assuming now that the cycle of operation shown in Fig. 2 has just been completed, and that the radio frequency signal persists, it will be seen that, owing to the aforementioned time constant of the circuit 3—4—5, the charge on the condenser 5 will not have been fully reduced to zero when the plate voltage again swings positive. Consequently, the plate-cathode voltage will be less than it was in the corresponding stage of the foregoing cycle. Hence, the critical voltage will be less negative than in the foregoing cycle (see Fig. 3), and hence the grid signal shown in Fig. 2 will no longer be able to control the firing of the tube, the grid being too negative to allow ionization. The result of this would be that the triode might fire only on every second or third positive plate voltage alternation and thus the average current through the load impedance would be materially reduced.

The superposition of the grid voltages of Fig. 2 on the plate and critical voltages of Fig. 3 will disclose that this effect may be compensated for by decreasing the negative grid bias. This has been accomplished, according to the present invention, by making the time constant of the resistance-capacity combination 9—10 of the order of, or preferably greater than the period of the alternating voltage supply. Then when the tube ionizes under conditions represented in Fig. 2, the negative grid will attract positive ions, thereby effectively reducing the direct current grid bias. In Fig. 3 this decreased grid bias is indicated, and it is clearly seen that ionization is again possible in spite of the decreased critical grid voltage also shown in Fig. 3.

Thus, the invention provides a means for supplying continuous direct current to a load in the plate circuit of a gas triode, and further provides a means to insure the reliable control of the triode by means of a radio frequency input signal.

A further aspect of the control circuit contributes to its reliability. Thus, assume that the high frequency signal impressed on the triode grid by way of the transformer 8 consists of a group of discrete high frequency wave trains, each having a duration, say, of one tenth second, and separated from the following wave train by a comparable length of time. Assume that the load 3 is a suitable relay designed to be energized by the gas triode, the energization to last for the duration of each discrete wave train. Assume further, by way of example, that five such wave trains are transmitted and that it is desired that the relay record each of the five wave trains without error. Conceivably these trains might arrive in such a weakened condition that the gas triode would fire only three times, the relay, therefore, being able to "count" only three units. However, the present invention tends to prevent such an occurrence, the relay either "counting" all or none of the received trains. This highly favorable situation is brought about as follows: Suppose that the first of a series of five wave trains arrives but is of such low signal strength as to fail to produce ionization. In this event, the effect of the signal upon the input circuit of the gas triode is to increase the electron current flowing through the circuit 9—10, and thus to increase the negative grid bias. The result is that the following wave trains in the series have even less chance of firing the triode than did the first, and hence while the relay 3 is not actuated at all, it also fails to give an inaccurate indication. On the other hand, as indicated hereinbefore, if the first wave train fires the triode, the grid bias is decreased, and hence possibility of following trains failing to fire the triode is very remote. Thus, a relay or other suitable utilization means energized by the circuit of the present invention tends to give either a correct indication of the received signals, or no indication at all.

An application of the present invention similar to that described is disclosed in the copending application of E. O. Thompson and D. Grimes, Serial No. 220,366, filed July 20, 1938, wherein the gas triode is employed to energize a step-by-step switch in a remote control circuit.

In a specific embodiment of the invention, which is not to be taken as limiting the invention, the following values were employed:

Resistor	9=50,000 ohms
Resistor	6= 4,000 ohms
Condenser	10=0.5 Mfd.
Condenser	7=0.1 Mfd.
Condenser	5=16 Mfd.
Resistor	4=150 ohms

Obviously, the invention is capable of various other modifications and embodiments without departing from its scope as defined in the appended claims.

I claim:

1. In a control circuit for gas triodes and the like, a gas triode having an input electrode and an output electrode, means for applying low frequency alternating current voltages of predetermined different phases and substantially fixed magnitudes to said electrodes, a load device connected to said output electrode, means for applying a bias voltage to said input electrode, means for applying a higher frequency signal to

said input electrode, the space path of said triode being rendered conducting in the presence of said signal for positive alterations only of the output electrode supply voltage, and means associated with said load device for maintaining a flow of current therein during the negative alterations of said output electrode supply voltage.

2. In a control circuit for gas triodes and the like, a gas triode having a grid, a cathode, and a plate, a source of low frequency alternating current voltage, means for applying a part of said voltage to said plate, phase shifting means for applying another part of said voltage to said grid, said phase shifting means including a resistor and a condenser, a load device connected to said plate, means for developing a self-bias voltage, means for applying said bias voltage to said grid, means for applying a radio frequency signal to said grid, the space path of said triode being rendered conducting in the presence of said signal for positive alternations only of the plate voltage, and means associated with said load device for maintaining a flow of current therein during the negative alternations of said plate voltage.

3. In a control circiut for gas triodes and the like, a gas triode having a grid, a cathode, and a plate, a source of low frequency alternating current voltage, connections for applying a part of said voltage between said cathode and plate, phase shifting means comprising at least a resistor and a condenser for applying another part of said voltage between said cathode and said grid, a load circuit included in the voltage supply connection to said plate a relatively large condenser in shunt with said load circuit, means including a resistor and condenser included in the voltage supply connection to said grid for developing a self-bias between said grid and cathode, and means for applying a radio frequency signal to said grid, the space path of said triode being rendered conducting in the presence of said signal for positive alternations only of the output electrode supply voltage.

4. In a control circuit as claimed in claim 3, the provision of a plate current limiting resistor in series with the relatively large shunt condenser.

5. In a control circuit for gas triodes and the like, a gas triode having a cathode, an input electrode, and an output electrode, an output circuit and output load connected to said output electrode, means for supplying a low frequency alternating current voltage to said output electrode, a source of bias voltage, a source of high frequency signal voltage, a source of alternating current voltage of said first-mentioned frequency and having a fixed phase and magnitude relationship with said first named alternating current voltage, and means for serially connecting said three voltage sources between said input electrode and said cathode, the space path of said triode being rendered conducting for positive alternations of said output electrode supply voltage but only in the combined presence of voltages from said three voltage sources.

6. In a control circuit for gas triodes and the like, a gas triode having a cathode, an input electrode, and an output electrode, an output circuit and an output load connected to said output electrode, means for supplying a low frequency alternating current voltage in series with said cathode, output electrode, output circuit and load, a source of bias voltage, a source of signal voltage, said signal voltage having a high frequency with respect to said first mentioned voltage, a source of alternating current voltage having a fixed predetermined phase and magnitude relationship with said first named alternating current voltage. means for serially connecting said three voltage sources between said input electrode and said cathode, the space path of said triode being rendered conducting for positive alternations of said output electrode supply voltage but only in the combined presence of voltages from said three voltage sources, and capacitive means associated with said output load for maintaining a flow of current therein during the negative alternations of said output electrode supply voltage.

7. In a control circuit for gas triodes and the like, a gas triode having a grid, a cathode, and a plate, a load impedance having one end connected to said plate, a capacitive reactance shunted across said impedance, a source of low frequency alternating current of fixed amplitude connected between the other end of said load impedance and said cathode, a phase-shifting network having one terminal connected to said cathode, a second source of alternating current of said low frequency connected between said cathode and the other terminal of said phase-shifting network, a source of intermittent high frequency signals, said last-named source being connected between said grid and a point on said phase-shifting network, and a resistance-capacitance self-biasing means included in said last-named connection, said last-named means having a time constant of the order of the period of said low frequency alternating current.

8. In a control circuit for gas triodes and the like, a gas triode having a grid, a cathode, and a plate, a load impedance having one end connected to said plate, a capacitive reactance shunted across said impedance, a source of low frequency alternating current of fixed amplitude connected between the other end of said load impedance and said cathode, a phase-shifting network having one terminal connected to said cathode, a second source of alternating current of said low frequency connected between said cathode and the other terminal of said phase-shifting network, a source of intermittent high frequency signals, said last-named source being connected between said grid and a point on said phase-shifting network, and a resistance-capacitance self-biasing means included in said last-named connection, said last-named means having a time constant greater than the period of said low frequency alternating current.

9. In a control circuit for gas triodes and the like, a gas triode having a grid, a cathode, and a plate, a load impedance having one end connected to said plate, a capacitive reactance shunted across said impedance, a source of low frequency alternating current of fixed amplitude connected between the other end of said load impedance and said cathode, a phase-shifting network comprising fixed impedances and having one terminal connected to said cathode, a second source of alternating current of said low frequency and of fixed amplitude connected between said cathode and the other terminal of said phase-shifting network, a source of intermittent high frequency signals, the amplitude of said signals being less than that of the current from said second source, said high frequency source being connected between said grid and a point on said phase-shifting network, and a self-biasing means comprising a resistance

shunted by a condenser serially included in said last-named connection, said last-named means having a time constant whose magnitude is at least of the order of the period of said low frequency alternating current.

10. In a control circuit for gas triodes and the like, a gas triode having a grid, a cathode, and a plate, a load impedance having one end connected to said plate, a source of low frequency alternating current of fixed amplitude connected between the other end of said load impedance and said cathode, a phase-shifting network having one terminal connected to said cathode, a second source of alternating current of said low frequency connected between said cathode and the other terminal of said phase-shifting network, the relation between the phases and magnitudes of said voltages remaining fixed and such that said gas triode remains just below the firing threshold, a source of intermittent high frequency signals, said last-named source being connected between said grid and a point on said phase-shifting network, and a resistance-capacitance self-biasing means included in said last-named connection, said last-named means having a time constant of the order of the period of said low frequency alternating current, the amplitude of said high frequency signal being small compared to that of either of the low frequency voltages, but sufficient to fire said triode when added to the voltage from said second source.

11. In a control circuit for gas triodes and the like, a gas triode having a grid, a cathode and a plate, means for applying low frequency voltages of like frequency but of unlike phase and amplitude to the grid-cathode and anode-cathode circuits of said triode, a load device connected to said anode-cathode circuit, means for applying a high frequency signal to said grid-cathode circuit, and means in said grid-cathode circuit for developing a self-bias in response to voltages of both said high frequency and said low frequency, the development of said self-bias being modified by the ionization of the gas in said gas triode.

12. In a control circuit for gas triodes and the like, a gas triode having an input electrode, an output electrode and a third electrode, means connected to said third electrode for supplying low frequency alternating current voltages of like frequency, different phases, and substantially fixed magnitudes to said input and output electrodes, a load device controlled by said gas triode, a circuit for applying a high frequency signal to said input electrode, the space path of said triode being rendered conducting in the presence of said signal, but only for positive alternations of the output electrode supply voltage, means connected to said load device for maintaining a flow of current therein during negative alternations of said supply voltage, and impedance means connected in the input circuit of said triode for establishing a unidirectional self bias whose magnitude is substantially proportional to the amplitude of said high frequency signal, said last mentioned means having a time constant so proportioned to the period of said low frequency alternating current that said bias voltage is automatically reduced in response to the ionization of the gas in said triode.

13. In a control circuit for gas triodes and the like, a gas triode having an input electrode, an output electrode and a third electrode, means connected to said third electrode for applying low frequency alternating current voltages of unlike phases and substantially fixed magnitudes to said electrodes, a load device connected to said output electrode, means for applying a high frequency signal to said input electrode, means for automatically biasing said input electrode according to the amplitude of said high frequency signal, and means responsive to the ionization of the gas in said triode for effecting an appreciable reduction in said bias, whereby to effect accurate response of said triode to signals.

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