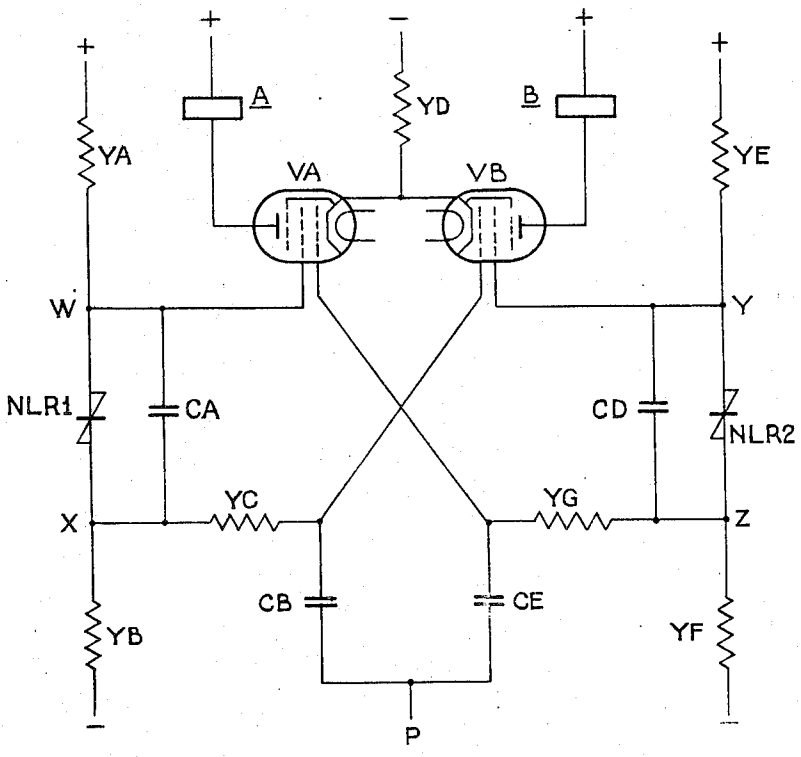
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ELECTRONIC TRIGGER CIRCUITS

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INVENTOR

GEORGE T. BAKER

By: Young, Emery & Thompson
Attys.

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ELECTRONIC TRIGGER CIRCUITS

George Thomas Baker, Liverpool, England, assignor to Automatic Telephone & Electric Company Limited, Liverpool, England, a company of Great Britain

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1

The present invention relates to electronic trigger circuits and is more particularly concerned with circuits employing a pair of back-coupled thermionic valves having two conditions of stable equilibrium and arranged so that the change from one state to the other takes place in response to an impulse applied to the control grids of the valves.

These arrangements have hitherto of necessity required a high voltage supply in order to provide a sufficiently large grid swing between the conducting and non-conducting conditions of the valves to ensure that such conditions are adequately maintained.

While the use of said high voltages is satisfactory in many circumstances it is a definite disadvantage when lower voltages only are normally available as in telephone exchanges, where a total E. M. F. of 100 volts, comprising 50 volts negative battery for speaking purposes and 50 volts positive battery for metering and the like, is available. In these circumstances a considerable proportion of the available voltage would have to be used to raise the potentials of the valve cathodes for grid bias purposes to ensure a sufficiently large grid swing and rectifiers would be necessary in the control grid circuits to discriminate between positive and negative impulses. Further it is often desirable when circuits of this nature are used in telephone systems and the like to be able to employ an electromagnetic relay in each anode circuit, one of the relays operating when the associated valve is conducting in one state of equilibrium. If, however, the cathode is raised to a high voltage level it follows that the potential difference available for the operation of the relay is limited and satisfactory operation is thereby prejudiced. Further, when such a relay or other inductive component is so employed and the trigger circuit embodies, for example, triode valves, the inductance in the anode circuit seriously limits the operating speed of the circuit.

A further disadvantage often encountered in trigger circuit is that only a fraction of the applied pulse is effective on the grids of the valves, while the remainder is dissipated in the circuit. This often necessitates the introduction of an amplifier in the input path of the stage with consequent increase in current consumption and cost.

The object of the present invention is to provide an improved trigger circuit which is not only capable of satisfactory operation on low voltages without the use of rectifiers but which also avoids the other disadvantages mentioned above.

According to one feature of the invention in order to reduce the high tension voltage necessary for the operation of the circuit, a non-linear

2

resistance is included in each coupling path between an electron-collecting electrode of one valve and the control grid of the other.

According to another feature of the invention, the steady potentials applied to the electron-collecting electrodes and the control grids of the valves are obtained from potentiometers each of which includes a non-linear resistance element, the positive end of said resistance element being connected to the electron-collecting electrode of one valve while the negative end is connected to the control grid of the other valve.

According to a further feature of the invention, a non-linear resistance element is associated with the circuit of each valve and serves to determine the steady potential applied to the control grid of the other valve, the voltage drop across said resistance element which controls the value of the resistance being dependent upon whether or not the associated valve is conducting.

Each non-linear resistance element is included in a potentiometer connected across the high tension supply and the arrangement is such that the voltage drop across the non-linear resistance element in the potentiometer associated with the non-conducting valve causes the non-linear resistance to be of low value and the voltage applied to the control grid of the conducting valve is then sufficiently positive with respect to the cathode to maintain the valve conducting while the voltage drop across the non-linear resistance in the other potentiometer causes the non-linear resistance to be of high value and the voltage applied to the control grid of the non-conducting valve is then considerably negative with respect to the cathode so that the possibility of triggering of the circuit by a positive pulse is minimised.

According to a further feature of the invention the triggering pulses are applied to the control grids of the valves and high value resistors are included between each point of application and the associated non-linear resistance element so that the whole of the triggering pulse is effective on the control grid and the use of amplifying stages is avoided.

According to a further feature of the invention, the valves employed in the trigger circuit are pentodes of which the cathode, control grid and screen grid of each valve act as a triode as regards the triggering operation while the windings of the electro-magnetic relays or other responding devices are arranged in the anode circuits of the valves and thus have substantially no effect on the triggering action.

The invention will be better understood from the following description of one method of carrying it into effect which should be read in conjunction with the accompanying drawing which

shows the circuit of a trigger circuit having an electro-magnetic relay in the anode circuit of each valve, one relay being operated when the circuit is in one stable state and the other being operated when the circuit is in the other stable state. The circuit thus operates as a frequency divider or a "scale of two" counter, the pulses obtained from each relay being at half the frequency of the input pulses.

The circuit is symmetrical both as regards connections and the values and characteristics of the corresponding components in the right and left hand halves.

For the purpose of the description it will be assumed that 100 volts battery supply is connected across leads + and — and when, by way of example, potentials are quoted those potentials will, unless otherwise specified, be positive with respect to the negative supply lead.

Consider first that a stable state exists whereby the pentode valve VB is conducting and the similar valve VA is non-conducting. Relay B will thus be operated while relay A will be normal.

The current flow through the valve VB will, due to the common cathode resistor YD, cause the cathodes to attain a positive potential and the value of the resistor YD is such that this potential reaches 22 volts. The potential of the cathodes is substantially constant during the operation of the circuit since one or other of the valves is always conducting and during the trigger action the current flow through the two valves is complementary.

Two potential dividers one comprising linear resistors YA and YB and non-linear resistor NLR1, and the other comprising linear resistors YE and YF and non-linear resistor NLR2 are connected across the 100 volt battery supply. The screen grids of valves VA and VB, which are used as auxiliary anodes, are connected respectively to points W and Y on the potential dividers while the control grid potentials are determined by the potentials derived from points X and Z. It will be noted that the inductance of the relay coils in the anodes is in effect isolated from the auxiliary anodes which control the triggering action of the circuit, and hence the frequency dividing function, and the circuit will therefore respond almost independently of the value of the relay inductance. It will of course be understood that the responding device need not be a relay but will in general be a device having an inductive impedance.

As regards the non-linear resistors NLR1 and NLR2, these, which may by way of example be discs of material known by the trade name "Atmite," have electrical characteristics whereby their resistance values change by a considerable amount inversely and instantaneously with a change of applied voltage.

Referring now to the typical conditions at present obtaining whereby the circuit remains adequately locked in its state of equilibrium, since valve VA is non-conducting the left hand potential divider is not affected by that valve and by suitably choosing the values of components YA, NLR1 and YB, potentials of 98 volts and 23 volts respectively are obtained at points W and X. The latter potential will be applied to the grid of valve VB and being 1 volt positive with respect to the cathode maintains that valve in its conducting condition. Since the valve VB is conducting the voltage distribution along the right-hand voltage divider is different from that along the left-hand divider, the valve current flowing

through YE causing a greater potential drop across this resistor than exists across resistor YA. It follows that the voltage across components NLR2 and YF is less than that across NLR1 and YB. The value of the non-linear resistor NLR2 is consequently high so that the potential at point Z is considerably less positive than point X. In practice potentials of approximately 50 volts and 4 volts are obtained at points Y and Z respectively. The potential at point Z is applied over resistor YG to the grid of valve VA and, being 18 volts negative with respect to the cathode, biases that valve considerably below cut-off.

It will be apparent that had linear resistors, each equal in value to the normal value of non-linear resistor NLR1, been placed in positions NLR1 and NLR2 the potential at point Z would have been more positive and the difference between the potentials on the grids of the two valves would in consequence have been less. It therefore follows that with the arrangement shown the available grid swing is greater than in the prior arrangement, and the magnitude of the bias on the non-conducting valve is such that, while the circuit may be made responsive to low value negative (with respect to the grid) pulses applied to the grids, the stable state is not affected by positive pulses unless they are of considerable value. The need for introducing rectifiers into the input pulse path is therefore eliminated.

When a negative pulse is applied to the input lead P the potentials on the control grids of the valves are made more negative. Valve VA which is already non-conducting is unaffected but since the grid potential of valve VB is reduced to cut-off the valve ceases to conduct, relay B releases and the screen voltage rises. The voltage at the point Y increases and this increase of voltage is applied through the condenser CD to the grid of the valve VA. The valve VA now conducts, relay A operates, and the voltage distribution along the two potential dividers is now reversed, the potentials at points W and X being 50 and 4 volts respectively while those at points Y and Z will be 98 and 23 volts respectively. The circuit is thus in the alternative state of equilibrium.

The effect of a subsequent negative pulse is to revert the circuit to its original state in a similar manner to that described.

It will now be apparent that with the present arrangement each of the relay coils will be energised due to alternate input pulses and with a suitable choice of relays, pulses up to a frequency of the order of 500 per second may be applied to derive pulses from each of the relays at half that rate. However input pulses at considerably higher rates than 500 per second may be employed and although the relays will not respond accordingly they will register the final condition of the circuit when impulsing has ceased.

The high value decoupling resistors YC and YG connected between the input pulse paths and points X and Z respectively in the potential dividers ensure that the input pulses are not appreciably dissipated through the potential dividers but act directly on the valve grids. This arrangement permits the use of pulses which are only slightly negative with respect to the grid of the conducting valve and therefore eliminates the necessity for introducing an amplifier stage in the input lead as would in some circumstances be necessary.

I claim:

1. An electronic trigger circuit comprising two thermionic valves each having at least a cathode,

a control grid and an electron-collecting electrode, a connection from each electron-collecting electrode to the control grid of the other valve whereby the circuit has two conditions of stable equilibrium, means for applying impulses to said circuit to cause a change from one condition of stable equilibrium to the other and a non-linear resistor included in each connection from the electron-collecting electrodes to the control grids, said non-linear resistor having a high value when the associated electron-collecting electrode is at a low potential and a low value when the associated electron-collecting electrode is at a high potential whereby the voltage necessary for the operation of the circuit is reduced.

2. An electronic trigger circuit comprising two thermionic valves each having at least a cathode, a control grid and an electron-collecting electrode, a connection from each electron collecting electrode to the control grid of the other valve whereby the circuit has two conditions of stable equilibrium, means for applying impulses to said circuit to cause a change from one condition of stable equilibrium to the other, a potential divider for each thermionic valve for applying steady potentials to the electron-collecting anodes and control grids of said valves, said potential dividers each including a non-linear resistor, the positive end of which is connected to the electron-collecting electrode of one valve while the negative end is connected to the control grid of the other valve so that the non-linear resistor has a high value when the associated electron-collecting electrode is at a low potential and a low value when said electron-collecting electrode is at a high potential.

3. An electronic trigger circuit comprising two thermionic valves each having at least a cathode, a control grid and an electron-collecting electrode, a connection from each electron-collecting electrode to the control grid of the other valve whereby the circuit has two conditions of stable equilibrium, means for applying impulses to said circuit to cause a change from one condition of stable equilibrium to the other, a non-linear resistor for each of said valves to determine the steady potential applied to the control grid of the other valve and a connection from the electron-collecting electrode of each valve to the associated non-linear resistor whereby the non-linear resistor has a high value when the associated valve is conducting and a low value when the associated valve is non-conducting and the potential applied to said control grid depends on the conducting or non-conducting condition of the associated valve.

4. An electronic trigger circuit comprising two pentode valves each having a cathode, a control grid, a screen grid, a suppressor grid and an anode, a common cathode resistor for said valves a connection between suppressor grid and cathode for each valve, a connection from each screen grid to the control grid of the other valve whereby the circuit has two conditions of stable equilibrium, means for applying impulses in common to said control grids to change the circuit from one condition of stable equilibrium to the other, a potential divider for each valve connected across the voltage supply for the circuit and comprising a first linear resistor, a non-linear resistor and a second linear resistor in that order, a connection between the positive end of said non-linear resistor and the screen grid of one valve whereby the non-linear resistor has a high value when the associated valve is conducting and a low value when said valve is non-conducting and a connection between the negative end of said non-linear resistor and the control grid of the other valve, the values of said linear resistors being so chosen that the potential applied to the control grid of the conducting valve from the potential divider associated with the non-conducting valve is sufficiently positive with respect to the cathode to maintain said valve in the conducting condition while the potential applied to the control grid of the non-conducting valve from the potential divider associated with the conducting valve is sufficiently negative with respect to the cathode to maintain said valve in the non-conducting condition and to minimise the triggering of the circuit by a positive pulse.

5. An electronic trigger circuit as claimed in claim 1 wherein the triggering pulses are applied to the control grids of the valves and a high-value resistor is included between each point of application and the associated non-linear resistor whereby the whole of the triggering pulse is effective on the control grid and the use of amplifying stages is avoided.

6. An electronic trigger circuit as claimed in claim 1 wherein the valves employed are pentodes of which the cathode, control grid and screen grid of each valve act as a triode as regards the triggering operation and the windings of inductive responding devices are arranged in the anode circuits of the valves.

7. An electronic trigger circuit comprising two pentode valves each having at least a cathode, a control grid, an electron-collecting electrode, a suppressor grid and an anode, a connection from each electron-collecting electrode to the control grid of the other valve whereby the circuit has two conditions of stable equilibrium, means for applying impulses to said circuit to cause a change from one condition of stable equilibrium to the other, a non-linear resistor included in each connection from the electron-collecting electrodes to the control grid and an inductive responding device connected in circuit with said anode whereby the effect of the inductance of said responding device on the potentials applied to the other electrodes is reduced.

8. Circuit arrangements comprising at least one thermionic valve having more than three electrodes, an inductive responding device, means for controlling the operation and restoration of said responding device in response to change in the operational condition of said valve due to voltage changes on certain of said electrodes and an additional electrode, said responding device being in circuit with said additional electrode to reduce the effect of the inductance of the responding device on the voltages applied to said electrodes.

GEORGE THOMAS BAKER.

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