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MULTIVIBRATOR TRIGGER CIRCUIT

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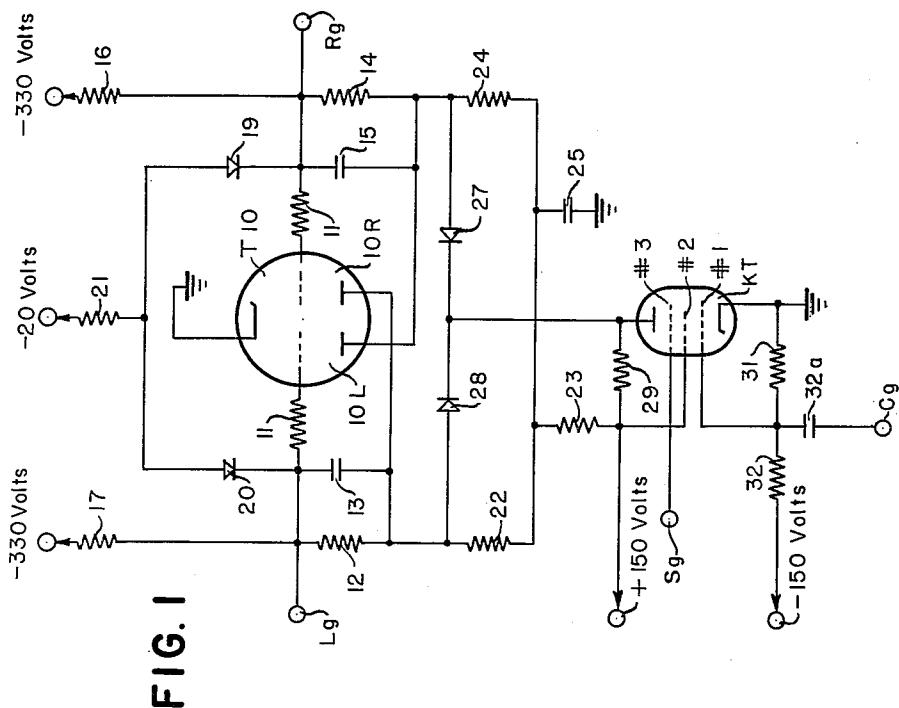


FIG. 1

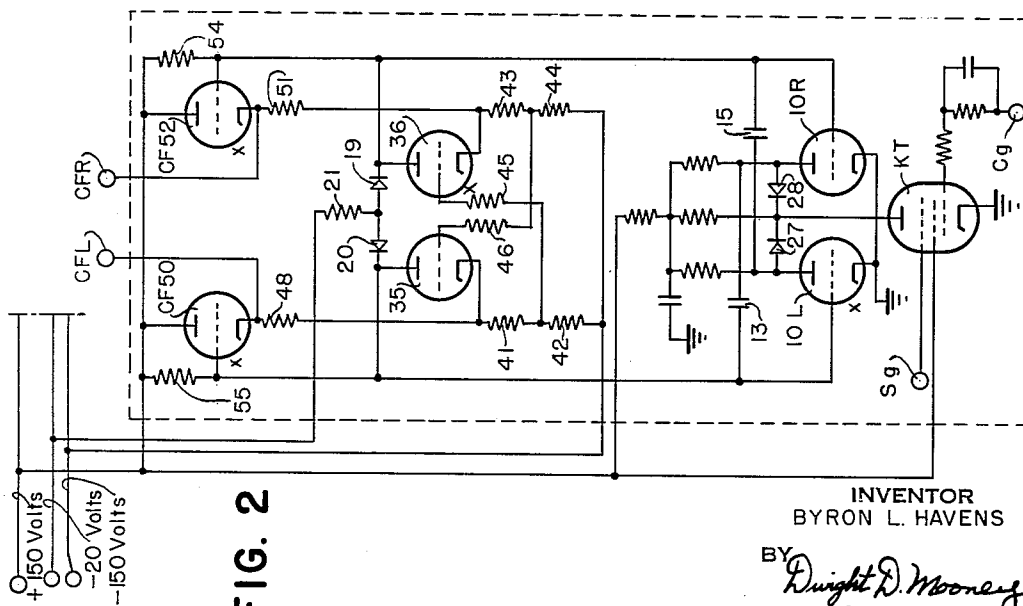


FIG. 2

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MULTIVIBRATOR TRIGGER CIRCUIT

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This invention relates to electronic switches and more particularly to an improved electronic switch having two stable conditions and employing a trigger circuit or a multivibrator.

It is well known in the art that the speed of operation of a trigger circuit of the Eccles-Jordan type is less than that of a similar multivibrator. For numerous switching purposes the multivibrator cannot be used because it is free running and does not therefore alternately assume two stable conditions.

Accordingly, the principal object of this invention is to provide an electronic switch having the operable speed of a multivibrator and two stable conditions alternately assumed by selective pulsing.

Another object is to provide a trigger circuit operable in response to pulses from a single source wherein means are provided between the source and its common connection to a plurality of points within the trigger circuit to automatically apply each pulse to a selected one of said points determined by the stable condition of the trigger circuit.

Another object is to provide a trigger circuit employing two grid controlled tubes and having two stable conditions alternately assumed wherein the voltage excursion at the control grid of each of the tubes is limited during operation of the trigger circuit, thereby decreasing the recovery time of the trigger circuit.

Another object is to provide a novel trigger circuit employing two tubes and having two stable conditions alternately assumed in which the actual triggering element per se is a multivibrator.

A further object is to provide a novel trigger circuit including a multivibrator having two stable conditions and a faster speed of operation than the corresponding trigger circuits of the prior art.

A still further object is to provide a trigger circuit employing a conventional multivibrator wherein the control grids of the tubes of the multivibrator are connected through resistors to a source of voltage supply to maintain the conductive tube of the multivibrator in its conductive condition until a subsequent pulse is applied to the multivibrator, and to provide clamping tubes to clamp the non-conductive tube of the multivibrator in its non-conductive condition until a subsequent pulse is applied, each of said clamping tubes being effective to override the action on the non-conductive tube of each of said resistors.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle. Other embodiments of the invention employing the same or equivalent principle may be used and structural changes made as desired by those skilled in the art without departing from the present invention and within the spirit of the appended claims.

In the drawings:

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Fig. 1 is a circuit diagram of a trigger circuit showing one embodiment of the invention, and

Fig. 2 is a circuit diagram showing another embodiment of the invention.

Briefly, this invention includes circuit means for limiting the negative voltage excursion on the grid of the non-conductive tube of a trigger circuit thereby permitting the voltage at that grid to be raised above its cutoff value when the trigger circuit is pulsed in less time and with greater ease than would otherwise be the case. Such limitation of the voltage excursion therefore decreases the recovery time of the trigger circuit thereby providing for faster speed of operation in response to an input pulse of lesser amplitude. The common input to the trigger circuit of the invention is applied thereto at a plurality of chosen points. Means are provided between these points and the common output to actually apply the input pulses to the single point which is then at such a polarity that the application of the input pulse thereto will effect a switching of the trigger circuit from one stable condition to the other.

These desirable features are also employed in a multivibrator circuit which the invention employs as a trigger circuit having two stable conditions alternately assumed. The control grids of the tubes of the multivibrator circuit are each connected through a resistor to a source of positive voltage to insure that the grid of the conductive tube of the multivibrator continues to have a positive voltage applied thereto. Clamping tubes are employed in a novel manner to override or counteract the effect of the resistor connected to the non-conductive tube thereby preventing any substantial change in the voltage at the control grid of either tube of the multivibrator until an input pulse is applied to the multivibrator.

Referring to Fig. 1 the trigger and keying circuit comprise the two triode trigger tubes shown in the single envelope T10, the left and right tube sections being designated by 10L or 10R respectively, and the keying tube by KT.

The grid of each of the tubes 10L and 10R has a parasitic suppressor resistor 11 connected thereto. The grid of the tube 10L is also connected through a resistor 12 and a capacitor 13 in parallel therewith to the plate of the tube 10R and the grid of the tube 10R is connected through a like resistor 14 and a like capacitor 15 in parallel therewith to the plate of the tube 10L. The grid of the tube 10R is also connected through resistor 16 to a source of suitable negative voltage, say -330 volts, the grid of the tube 10L is connected through a like resistor 17 to the same voltage source. These control grids are also connected through the rectifiers 19 and 20 and their point of common juncture is connected through a resistor 21 to a suitable source of negative voltage, say -20 volts. The plate of the tube 10R is connected through resistors 22 and 23 to a suitable source of plate supply voltage, say +150 volts and the plate of the tube 10L is similarly connected through resistors 24 and 23. The juncture of resistors 22 and 24 is connected through capacitor 25 to ground to provide decoupling from circuits external to the trigger circuit.

The plates of the tubes 10L and 10R are also connected together through the rectifiers 27 and 28 respectively and the juncture connected directly to the plate of the keying tube KT. The plate of the tube KT is also connected through load resistor 29 to the source of positive plate supply voltage to which the grid #2 of tube KT is also connected. The cathode of tube KT is connected directly to ground as is the common cathode of tube T10. The grid bias resistor 31 is connected to ground and through grid bias resistor 32 to a source of negative voltage, say -150 volts. The grid #1 of tube KT is connected directly to the juncture of resistors 31 and 32.

The grid #3 (suppressor grid) of the tube KT is connected to a terminal *sg* and grid #1 (control grid) is connected to a terminal *cg* through condenser 32a. The terminals *sg* and *cg* are provided to receive positive voltages so that the keying tube KT may be rendered conductive at preselected times when such positive voltages are simultaneously applied to the two terminals. The terminals *Lg* and *Rg* connected to the control grids of tubes 10L and 10R respectively are provided to convey outputs from those respective tubes.

In operation the trigger circuit associated with the tube T10 performs in a manner very similar to that of a conventional Eccles-Jordan trigger circuit in that the trigger circuit alternately assumes each of two stable conditions in response to the plate current conduction of the keying tube KT. When in one of these stable conditions the tube 10L is conductive and the tube 10R is non-conductive. This condition is referred to herein as the Left condition. When in the other stable condition the tube 10L is non-conductive and the tube 10R is conductive. This condition is referred to herein as the Right condition. The trigger circuit may be initially placed in one chosen stable condition by any conventional means, such as, temporarily applying a different grid bias to the two tubes 10R and 10L. Assuming that the trigger circuit is in the Left condition, the voltage at the plate of the conductive tube 10L is low, the voltage of the non-conductive tube 10R is high, the voltage at the terminal *Lg* is high, and the voltage at the terminal *Rg* is low.

When suitable positive pulses are simultaneously applied to the terminals *cg* and *sg* of the keying tube KT that tube is rendered plate current conductive and accordingly produces a voltage drop at the juncture of rectifiers 27 and 28. Obviously, since the trigger circuit is in the Left condition the inverse voltage drop across the rectifier 28 prior to conduction of the tube KT is less than that across the rectifier 27. Hence, conduction results through the rectifier 28 to lower the voltage at the grid of the tube 10L. As a result conduction through tube 10L is decreased and the corresponding voltage increase at its plate is transferred through resistor 14 and capacitor 15 in parallel therewith to the control grid of the tube 10R to render it conductive. The corresponding voltage decrease at the plate of tube 10R is transferred through resistor 12 and capacitor 15 in parallel to the control grid of the tube 10L to render it still less conductive. This cumulative action is continued until the tube 10L is rendered non-conductive and the tube 10R is rendered fully conductive to place the trigger circuit in the Right condition.

Since, the rectifier 27 is connected between the plate of the tube 10L and the plate of the tube KT and since both these plates are at relatively low voltages when the trigger circuit is keyed from the Left condition the keying voltage applied to the grid of the tube 10L is not applied to the tube 10R. Hence, the voltage drop at the juncture of rectifiers 27 and 28 is routed to the grid of the conductive trigger tube and is not applied to the grid of the non-conductive trigger tube. The rectifiers 27 and 28 also prevent the voltage at the plate of the keying tube KT from decreasing below the voltage at the plate of the corresponding tubes 10L and 10R respectively. Such is the case because when the voltage at the plate of the tube KT tends to become less than that at the plate of either of the tubes 10L or 10R current is passed there-through tending to equalize the voltage difference between the respective plates. This selective application of pulses from a common source to the grids of the tubes 10L and 10R permits a more positive switching of the trigger circuit than is realized when each pulse from the common source is applied to both tubes.

The rectifiers 19 and 20 are provided to limit the voltage excursion at the control grid to which each is connected to -20 volts which is the value of the voltage commonly applied to the other terminal of the rectifiers.

This limiting of the voltage excursion decreases the recovery time of the trigger circuit and therefore permits a faster switching thereof.

It is now clear that each simultaneous application of suitable positive pulses to the terminals *sg* and *cg* connected to the keying tube KT causes an output pulse to appear at each of the terminals *Lg* and *Rg*. When the trigger circuit is switched to the Right condition the output pulse at the terminal *Lg* is negative and that at the terminal *Rg* is positive and when the trigger circuit is switched to the Left condition the polarity of these respective output pulses is reversed.

Referring to Fig. 2 the trigger circuit includes a keying tube KT which functions as the keying tube KT shown in Fig. 1. The tubes 10L and 10R are connected to function as a multivibrator. The multivibrator circuit is similar to the trigger circuit of Fig. 1 except that the resistive connection between the plate of each tube and the control grid of the other is omitted. This is a conventional change to effect conversion of a trigger circuit to a multivibrator circuit.

The trigger circuit of Fig. 2 retains the desirable features of a multivibrator in that there is no resistive coupling between the plate of each trigger tube and the control grid of the other. The frequently objectionable feature of a multivibrator used as an electronic switch, namely, that it is free running and cannot be switched from one stable condition to the other, is overcome by the use of clamping tubes 35 and 36.

The plate of each of the tubes 35 and 36 is connected through the respective rectifiers 20 and 19 and the resistor 21 to a suitable source of negative supply voltage, say -20 volts. The cathode of the tube 35 is connected to a suitable source of negative voltage, say -150 volts, through the resistors 41 and 42 and the cathode of tube 36 is similarly connected through the resistors 43 and 44. The control grid of tube 35 is connected through a resistor 46 to the junction of resistors 43 and 44 and the control grid of tube 36 is connected through a resistor 45 to the juncture of resistors 41 and 42.

The cathode of tube 35 is also connected through a resistor 48 to the cathode of cathode follower tube CF50 and the cathode of tube 36 is connected through a resistor 51 to the cathode of cathode follower tube CF52. The plates of the tubes CF50 and CF52 are connected directly to the +150 volt supply. The grid of the tube 10R, the plate of the tube 36, and the grid of the tube CF52 are commonly connected through a resistor 54 to a suitable source of positive supply voltage, for example, +150 volts. The grid of the tube 10L, the plate of tube 35, and the grid of tube CF50 are commonly connected through a resistor 55 to the +150 volt supply. The cathodes of the tubes CF50 and CF52 are connected to output terminals CFL and CFR respectively.

The cathode follower tubes CF50 and CF52 are both always conductive regardless of the conductive condition of tubes 10L, 10R, 35 and 36. The conductivity of tubes CF50 and CF52 is indicated by an X to the lower left of the respective tubes. When the multivibrator tube 10L is conductive the tube 35 is non-conductive and when the multivibrator tube 10R is conductive the tube 36 is non-conductive. The rectifiers 20 and 19 are connected between the -20 volt supply and the control grids of the tubes 10L and 10R tend to prevent those control grids from going below the -20 volts and therefore determine the most negative positions of the grids of the multivibrator tubes 10L and 10R. The rectifiers prevent those grids from reaching a voltage as negative as they would otherwise reach, it therefore takes less time and less power for a pulse to effect a switching of the multivibrator from one stable condition to the other than would be the case if the rectifiers were not employed.

In operation, the cathode follower tubes CF50 and CF52 are always conductive. For purposes of explanation, it is assumed that the tubes 10L and 36 are initially

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conductive, as indicated by the x to the lower left of the respective tubes, and the tubes 10R and 35 are initially non-conductive. When the keying tube KT is rendered plate current conductive, as previously described, a decreased voltage is applied to the commonly connected terminals of the rectifiers 27 and 28 and tends to cause conduction through a preselected one of the rectifiers as set forth previously herein. A negative pulse is transferred through the capacitor 13 to the control grid of the tube 10L. Conduction through the tube 10L is decreased and a positive voltage is transferred through capacitor 15, connected to its plate, to the control grid of the tube 10R to render it conductive.

The accumulative action above described then switches the multivibrator to the Right condition. This condition causes a positive voltage to be applied to the control grid of the cathode follower tube CF52 to render it more conductive and a negative voltage to be applied to the control grid of the cathode follower tube CF50 to render it less conductive. The resulting increased voltage at the cathode of tube CF52 is transferred to the terminal CFR and through voltage dividers to the cathode of clamping tube 36 and the control grid of clamping tube 35. The decreased voltage at the cathode of the tube CF50 is transferred to the terminal CFL and through voltage dividers to the grid of clamping tube 36 and the cathode of clamping tube 35.

The effect of this simultaneous application of these voltages to the tubes 35 and 36 is twofold. The application of these voltages to the grid and the cathode of the tube 36 sufficiently increases or raises the potential of the cathode relative to the grid to thereby render the tube 36 non-conductive. The application of these voltages to the control grid and cathode of the tube 35 renders tube 35 conductive. The resulting plate current of the tube 35 is applied to the control grid of the cathode follower tube CF50 and the control grid of the multivibrator tube 10L. This current counteracts the tendency of the current through resistor 55 to hold these grids at a voltage as near +150 volts as the grid current of multivibrator tube 10L will permit. The steady plate current drawn from the control grid circuit of the tube 10L by tube 35 when it is conductive assures that the grid of the tube 10L will remain below cut off and that the multivibrator will remain in the Right condition until the keying tube KT is again rendered conductive. The non conduction of tube 36 permits the current through resistor 54 to tend to raise the voltage at the control grid of the tube 10R thereby insuring that the voltage on that control grid will remain sufficiently positive to cause conduction through the tube 10R until keying tube KT is again rendered conductive.

Subsequent plate current conduction of the keying tube KT will in like manner cause a switching of the stable condition of the multivibrator from the Right condition to the Left condition, render clamping tube 35 non-conductive and clamping tube 36 conductive, decrease the conduction through cathode follower tube CF52, increase the conduction through cathode follower tube CF50 and provide increased and decreased voltages respectively at the terminals CFL and CFR. It is now clear that the clamping tubes 35 and 36 function to relieve the positive voltage locking action of the resistor 54 or 55 on the control grid of the non-conductive multivibrator tube and permit a locking of positive voltage at the control grid of the conductive multivibrator tube and effect a locking of negative voltage at the control grid of the non-conductive multivibrator tube between periods of conduction of keying tube KT.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without

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departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. An electronic switching circuit having two stable conditions represented by an alternate conduction and non-conduction of each of two grid controlled tubes; a source of pulses for switching said circuit from each stable condition to the other; means consisting only of a pair of rectifiers and a resistor connected between the control grid of each of said tubes and a first constant potential for limiting the negative voltage excursion thereon to a predetermined value thereby decreasing the recovery time of said circuit; means directly connecting the cathodes of each of said tubes in common to a second constant potential such that said cathodes are at all times maintained at said second constant potential; and a rectifier connected to the control grid of each of said tubes and said source so that each pulse from said source will be applied only to the control grid having the most positive voltage thereon.

2. In a trigger circuit having two grid controlled tubes and two stable conditions alternately assumed in response to each selected pulse applied thereto; rectifiers connected between the control grid of each of said tubes and a source of constant bias voltage to limit the voltage excursion on said grids to a value at least as positive as the voltage value at said source; circuit means for maintaining the potential of the cathodes of each of said tubes at a constant value; a coupling network connected between the plate of each tube and the control grid of the other; a source of pulses for switching the trigger circuit from one stable condition to the other and connections therefrom to an input terminal; and pulse selective means responsive to a predetermined voltage difference thereacross and connected between said terminal and each of said tubes so that a single selected pulse is applied to a preselected one of said tubes to switch said trigger circuit from each stable condition to the other, said preselected tube being determined by the stable condition of said trigger circuit.

3. An electronic switch operable in response to preselected voltage pulses and having two stable conditions including a free running multivibrator having two cross-connected grid controlled tubes alternately conductive and non-conductive and vice versa; and means for alternately holding each of said tubes in a conductive and non-conductive condition and vice versa to represent said two stable conditions, said means including two electronic clamping tubes each having an electrode coupled to a different one of the grid controlled tubes of the multivibrator so that a certain predetermined voltage change at either of said grid controlled tubes is transferred to said clamping tubes to reverse the conductive condition of each of the clamping tubes, and a connection from each clamping tube to a different one of said grid controlled tubes to transfer a steady voltage thereto thereby preventing said grid controlled tubes from automatically changing their conductive condition.

4. The electronic switch set forth in claim 3 wherein each clamping tube is coupled to the control grid of a different one of the grid controlled tubes through a cathode follower tube having its control grid connected directly to the control grid of one of the multivibrator tubes and also connected to a source of positive voltage through a resistor; and the cathode of each cathode follower is connected to the cathode of one clamping tube and a grid of the other clamping tube.

5. A trigger circuit having two stable conditions including a multivibrator employing two grid controlled tubes alternately conductive and non-conductive and vice versa to represent two conductive conditions; a source of pulses connected to said multivibrator to effect an increase in the conduction of one of said tubes thereby causing a switching thereof from one conductive condition to the other; a resistive connection from the control grid of each

tube of the multivibrator to a positive voltage supply to apply a positive voltage to the control grid of one of said tubes thereby holding it in a conductive condition; a connection from the plate of each tube of the multivibrator to the control grid of a cathode follower tube to change the conductivity of the latter when the conduction of the tube of the multivibrator connected thereto is increased in response to a pulse from said source; two grid controlled tubes, each having its control grid and cathode connected to the cathode of a different one of said cathode follower tubes so that a change in the conductivity of one of said cathode follower tubes effects opposite conductive changes in each of said clamping tubes thereby changing the conductive condition of each of the clamping tubes; and a connection from each clamping tube to a different one of the tubes of the multivibrator to transfer a voltage change to the latter to counteract the effect of the voltage applied thereto through said resistive connection and apply voltage of suitable polarity to the tubes of said multivibrator to effect a switching thereof to the other conductive condition in response to each of said pulses and apply voltages of suitable polarity to effect a holding of each of said tubes in that condition of conductivity until the next subsequent pulse is applied to said multivibrator.

6. In a trigger circuit employing a multivibrator having a first grid-controlled tube and a second grid-controlled tube; a source of input pulses, electronic circuit means for causing the multivibrator to alternately assume each of two stable conditions in response to input pulses applied thereto; a clamp circuit means including a first triode having an anode, a cathode and a control grid, a second triode having an anode, a cathode and a control grid, a first resistor connecting the cathode of said first triode to the control grid of said second triode, a second resistor connecting the cathode of said second triode to the control grid of said first triode, a direct connection between the anode of said first triode and the control grid of said first tube and a direct connection between the anode of said second triode and the control grid of said second tube, whereby

each of said pulses is applied to a preselected point of the multivibrator as determined by the stable condition thereof.

7. An electronic switching circuit including a multivibrator having first and second cross-connected grid controlled tubes; a source of input pulses and a connection therefrom to a plurality of points of the multivibrator having different voltages applied thereto; rectifier means connected between said source and said points to apply each of said pulses to the one of said points at which is present an extreme voltage value; a holding resistor connected to a source of positive voltage for holding each tube of said multivibrator in its conductive condition; and pulse responsive electronic means including a first triode having an anode, a cathode and a control grid, a second triode having an anode, a cathode and a control grid, a first resistor connecting the cathode of said first triode with the control grid of said second triode, a second resistor connecting the cathode of said second triode with the control grid of said first triode, a direct connection between the anode of said first triode and the control grid of said first grid-controlled tube, and a direct connection between the anode of said second triode and the control grid of said second grid-controlled tube, whereby the holding action of said holding resistor is relieved when each input pulse is applied to each of said points of said multivibrator.

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