

May 26, 1953

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2,640,153

TRIGGER CIRCUIT

Filed Dec. 29, 1951

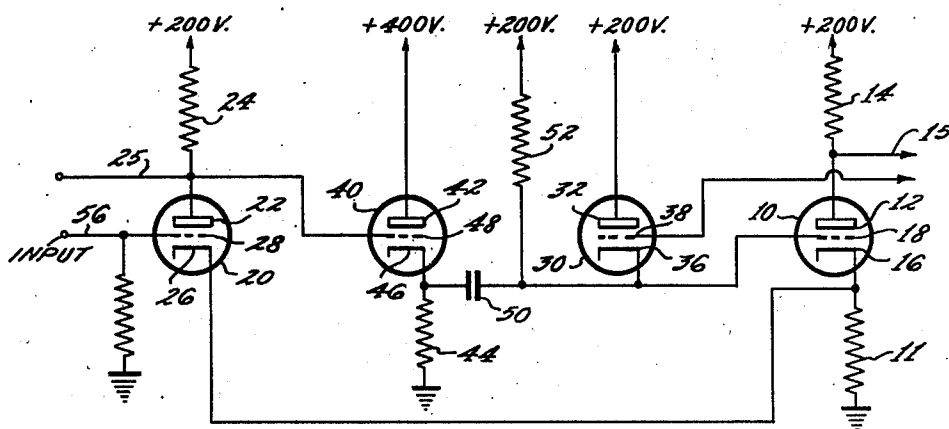


Fig. 1.

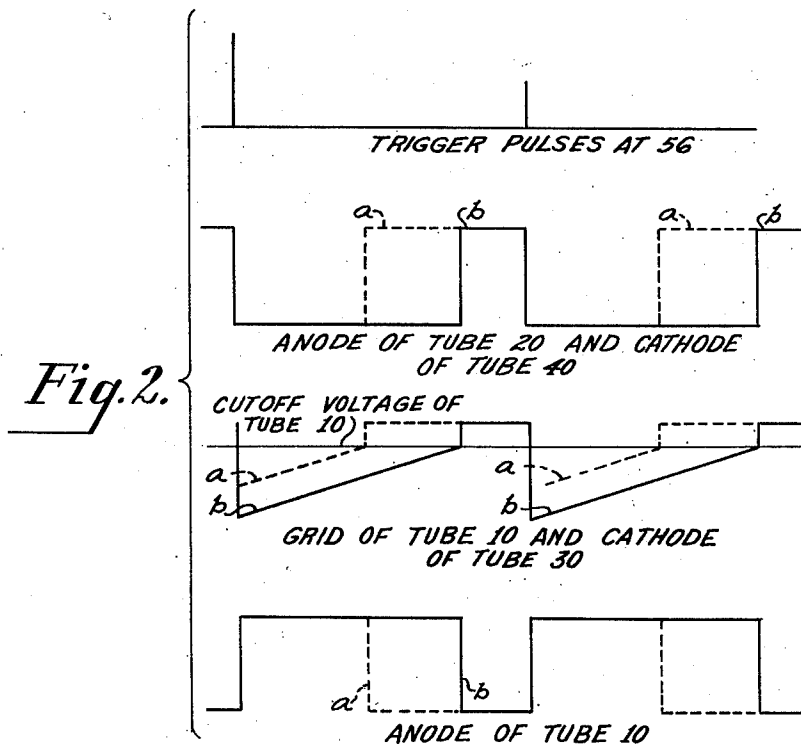


Fig. 2.

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2,640,153

TRIGGER CIRCUIT

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Application December 29, 1951, Serial No. 264,091

5 Claims. (Cl. 250—27)

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This invention relates to electronic trigger circuits and, in particular, to an improved slide-back or self-restoring trigger circuit.

Slide-back trigger circuits are of the type having only one degree of stability. Such circuits have a stable state and an unstable state. They remain in the stable state until tripped into the unstable state by a voltage pulse of suitable polarity and magnitude. After a predetermined interval of time in the unstable state, determined primarily by the time constants of the circuit elements, the trigger circuit returns or restores itself to the stable state and so remains until again tripped by a suitable voltage. The slide-back trigger circuit provides an output pulse which has a width or duration equal to the duration of its unstable state. A description of several types of slide-back trigger circuits may be found in "Electron Tube Circuits" by Samuel Seely, pages 414-418, published in 1950 by the McGraw-Hill Publishing Co., Inc.

The conventional slide-back trigger circuit has a fixed unstable-state period which is determined by the values of the circuit constants used in certain portions of the circuit. Such a slide-back trigger circuit is not designed to permit a rapid variation in the unstable-state duration and cannot be controlled without directly affecting the triggering action. Slide-back triggers find use as timers, time delay devices and the like. It is desirable in many such applications of slide-back trigger circuits to be able to vary rapidly the duration of the output pulse obtained while maintaining isolation from the control source.

It is an object of the present invention to provide a slide-back trigger circuit having an improved pulse-width control.

Another object of the present invention is to provide a self-restoring trigger circuit having an improved restoring-time control.

A further object of the present invention is to provide a slide-back trigger circuit wherein the unstable state period may be varied rapidly.

A still further object of the present invention is to provide a slide-back trigger circuit wherein the unstable-state-period control is isolated from the trigger circuit.

In accordance with the invention, certain of the foregoing objects and advantages of the invention are attained by utilizing a pair of cathode-coupled electron discharge tubes, having a stable condition and an unstable condition. In the stable condition a first one of said pair of tubes is conductive and the second one of said

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pair of tubes is non-conductive. In the unstable condition the first tube is non-conductive and the second tube conductive. The grid of the first tube is connected to the cathode of a third electron discharge tube. The third tube is normally biased beyond cut-off by means of a large voltage applied to its cathode through a bias resistor.

The anode of the second tube is condenser-coupled to the control grid of the first tube through a cathode-follower stage, which includes a fourth electron discharge tube. The bias resistor provides a charging path for the condenser and also serves to positively bias the control grid of the first tube in the stable state.

A variable direct-current bias is applied to the control grid of the third tube. This bias determines the magnitude of the negative voltage applied to the grid of the first tube at the beginning of the unstable state. Rectangular pulse outputs are derived from the anodes of the first and second tubes by means of separate output terminals. The width of the rectangular pulse may be varied by varying the direct-current bias applied to the grid of the third tube.

The novel features of the invention as well as the invention itself, both as to its organization and method of operation, will best be understood from the following description, when read in connection with the accompanying drawings in which:

Figure 1 is a circuit diagram showing a preferred embodiment of the invention and

Figure 2 illustrates the voltage wave shapes existing in various portions of the circuit of Figure 1 during its operation.

Two electron discharge tubes 10 and 20 have their cathodes 16 and 26 connected to a common cathode biasing resistor 11. The anode 12 of the first tube 10 is connected through an anode load resistor 14 to a suitable source of operating potential. Similarly, the anode 22 of the second tube 20 is connected through an anode load resistor 24 to a source of operating potential. Separate output terminals 15 and 25 are connected to respective anodes 12 and 22 of the first and second tubes. The grid of the first tube is connected to the cathode of a third electron discharge tube 30. The anode 32 of the third tube is connected directly to the source of operating potential. A variable direct-current bias is applied to the grid 38 of the third tube. An input terminal 56, to which positive triggering pulses are applied, is connected to the grid of a fourth electron discharge tube 40. The anode 42 of the

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fourth tube 40 is connected directly to a source of operating potential. The cathode 46 of the fourth tube 46 is connected to a cathode load resistor 48 and is coupled through a coupling condenser 50 to the grid 18 of the first tube 10. A positive potential is applied to the grid 18 of the first tube and to the cathode 36 of the third tube through a bias resistor 52.

With the above connections, the following stable state conditions are present in the circuit. The grid of the first tube 10 is positive with respect to its cathode 16 and consequently, the first tube 10 is normally conducting. The conduction of the first tube 10 develops a bias across the common cathode biasing resistor 11 which is effective to cut off conduction in the second tube 20. Thus, the second tube is normally non-conductive in the stable state. The third tube has a high positive potential on its cathode and is biased beyond cut-off by an amount which is determined by the direct-current voltage applied to its grid. The grid bias of the fourth tube is positive in respect to its cathode and consequently the fourth tube is normally conducting. The fourth tube, as will be seen, is continuously conducting although the amount of its conduction varies.

The triggering action is initiated by applying a positive triggering pulse such as is shown in Figure 2 to the input terminal 56. This pulse is of such a magnitude that the second tube starts to conduct and consequently its anode potential drops as shown in Figure 2. The negative change of anode potential of the second tube is applied to the grid 40 of the fourth tube 40 and causes a sharp decrease in current therethrough. This sudden decrease in current through the fourth tube causes a drop in its cathode potential (shown in Figure 2) which is coupled through the coupling condenser 50 to the grid 18 of the first tube and the cathode 36 of the third tube 30 (shown in Figure 2). The negative voltage applied to the grid 18 of the first tube 10 causes a decrease in current through that tube and a decrease of degenerative cathode bias applied to the cathode 26 of the second tube 20 which aids the initial change of current in the second tube due to the trigger pulse. The regenerative action between the first and the second tubes continues until the third tube is caused to conduct. The regenerative action occurs very rapidly and, as shown in Figure 2, is substantially instantaneous. The maximum point of the negative excursion of the voltage applied to the grid of the first tube is determined by the grid-to-cathode voltage which causes the third tube 30 to conduct. This is the cut-off bias of the third tube and may be varied by varying its grid bias.

Thus, the direct-current bias applied to the grid of the third tube determines the magnitude of the negative excursion of the voltage applied to the grid of the first tube at the initiation of the unstable state. The direct current bias applied to the third tube also determines the time of duration of the unstable state since the rate of return remains constant and substantially linear. This is shown in Figure 2 where two tube grid bias conditions *a* and *b* are shown. As a larger negative grid excursion is permitted, the time of duration of the unstable state is increased.

The first tube 10 is held cut off by the negative potential across the coupling condenser 50 until the coupling condenser discharges through a series path comprising two resistors 52 and 44. When the coupling condenser 50 has discharged

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to the cut-off point of the first tube 10, the first tube conducts and cuts off the conduction of the second tube by means of the cathode degeneration across the common cathode biasing resistor 11. This last change marks the return of the circuit to the stable state and occurs almost instantaneously because the fourth tube 40 provides a low impedance charging path for the coupling condenser 52 and consequently causes the grid of the first tube to rise very rapidly to its stable positive condition.

The invention may be practiced without the use of a cathode-follower coupling between the second tube 20 output and the first tube 10 input as is provided by the fourth tube 40. The provision of the cathode-follower stage, however, isolates the output circuit connected to the anode of the second tube from the remainder of the circuit and also provides a low impedance charging path for the coupling condenser 52 which allows a rapid return to the stable state when the grid 18 of the first tube 10 reaches its cut-off point.

From the foregoing description, it will be readily apparent that the invention provides a novel and improved slide-back trigger circuit having a pulse-width or restoring-time control which may be varied rapidly without affecting the triggering operation of the circuit.

What is claimed is:

1. A slide-back trigger circuit comprising first and second electron discharge tubes each having at least a cathode, an anode, and a control grid, a cathode bias resistor to which the cathodes of said first and second tubes are connected, means coupling the anode of said second electron discharge tube to the grid of said first tube, said means including a capacitor connected to the grid of said second electron discharge tube, a third electron discharge tube having a cathode, an anode and a control grid, said third tube having its cathode connected to the grid of said first tube, separate plate-load resistors coupled to the anodes of said first and second tubes, a bias resistor connected to the cathode of said third tube, means to apply trigger pulses to the grid of said second tube, means to derive an output from the anodes of said first and second tubes, and means to apply a variable direct-current input to the grid of said third tube, whereby the time of duration of the slide-back trigger output pulse may be varied.

2. In a single-stable-state trigger circuit, a first and a second electron discharge tube each having at least a cathode, an anode, and a control grid, a cathode bias resistor to which the cathodes of said first and second tubes are connected, means to couple the anode of said second tube to the control grid of said first tube including a capacitor connected to the grid of said first tube, a third electron discharge tube having at least a cathode, an anode, and a control grid, said third tube having its cathode coupled to the control grid of said first tube, a bias resistor coupled to the cathode of said third tube, separate anode load resistors connected to the anodes of said first and second tubes, means to apply operating potential to said anode load resistors, said bias resistor and the anode of said third tube, means to apply a trigger pulse to the control grid of said second tube, means to apply a variable direct-current bias to the control grid of said third tube, whereby the length of duration of the unstable state of said trigger

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circuit after its initiation by said trigger pulse may be varied.

3. In combination, a first and a second electron discharge tube each having at least a cathode, an anode, and a control grid, means including a capacitor to couple the anode of said second tube to the control grid of said first tube, a cathode bias resistor to which the cathodes of said tubes are connected, a third electron discharge tube having at least a cathode, an anode, and a control grid, a connection between a cathode of said third tube and the junction of said capacitor and the control grid of said first tube, an anode load resistor coupled to the anode of said second tube, a second anode load resistor connected to the anode of said first tube, a bias resistor connected to the cathode of said third tube, means to apply operating potential to said anode load resistors, said bias resistor and the anode of said third tube, means to apply a trigger pulse to the grid of said first tube, means to apply a variable direct-current voltage to the grid of said third tube, means to derive an output from the anodes of said first and second tubes.

4. The combination is recited in claim 3 wherein the means including a capacitor to couple the anode of said second tube to the grid of said first tube includes, a fourth electron discharge tube having at least a cathode, an anode, and a control grid, said fourth tube having its control grid connected to the anode of said second tube, a cathode bias resistor connecting to the cathode of said fourth tube, a connection between the cathode of said fourth tube and said capacitor, whereby the anode load resistor of said second tube is isolated from the charging path of said capacitor and the speed of operation of said trigger circuit is improved.

5. A slide-back trigger circuit having a stable

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state and an active state comprising a first and a second electron discharge tube each having at least a cathode, an anode, and a control grid, a cathode bias resistor to which the cathodes of said first and second tubes are connected, whereby said second tube is normally non-conductive and said first tube is normally conductive in the stable state and conversely in the active state, a third electron discharge tube having at least a cathode, an anode, and a control grid, a connection between the control grid of said first tube and the cathode of said third tube, a bias resistor, a connection between said bias resistor and the cathode of said third tube, a fourth electron discharge tube having at least a cathode, an anode, and a control grid, a connection between the anode of said second tube and the control grid of said fourth tube, a cathode bias resistor connected to the cathode of said fourth tube, a connection between the cathode of said fourth tube and one end of a capacitor, a connection between the other end of said capacitor and the control grid of said first tube, means to apply operating potentials, means to apply a positive triggering pulse to the control grid of said second tube, means to apply a variable direct-current bias to the grid of said third tube, means to derive an output at the anodes of said first and second tubes, whereby a rectangular pulse may be derived having a pulse duration, after initiation by a triggering pulse, determined by the value of direct-current voltage applied to the grid of said third tube.

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