

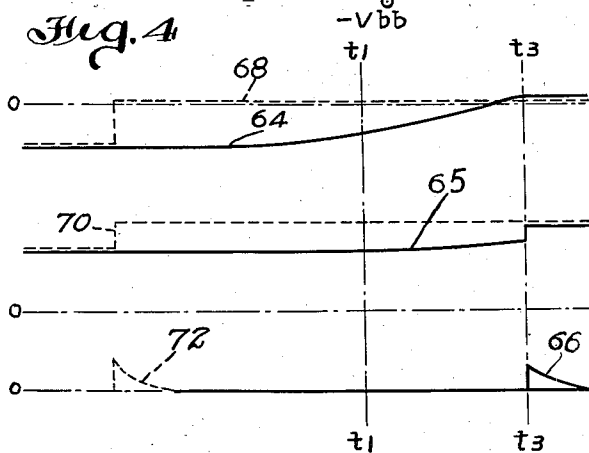
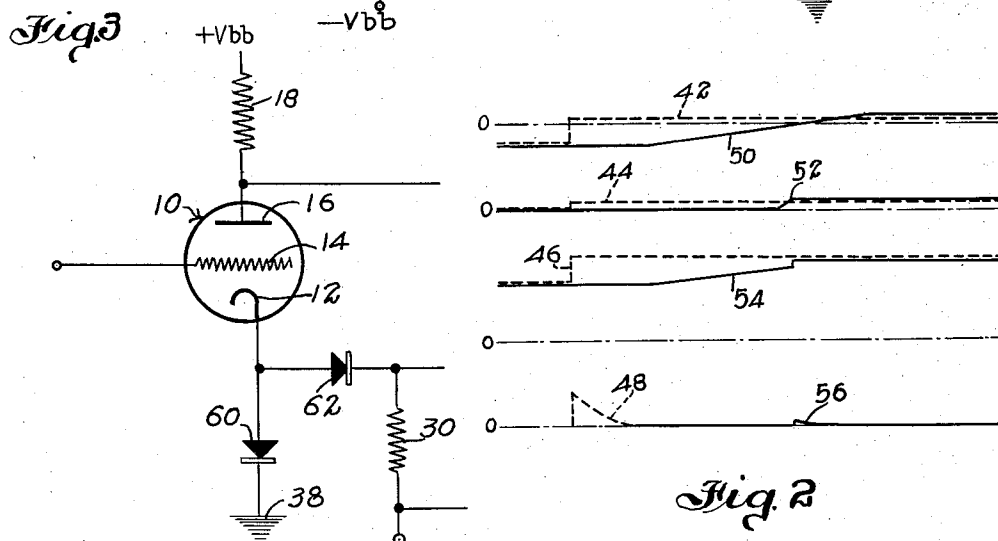
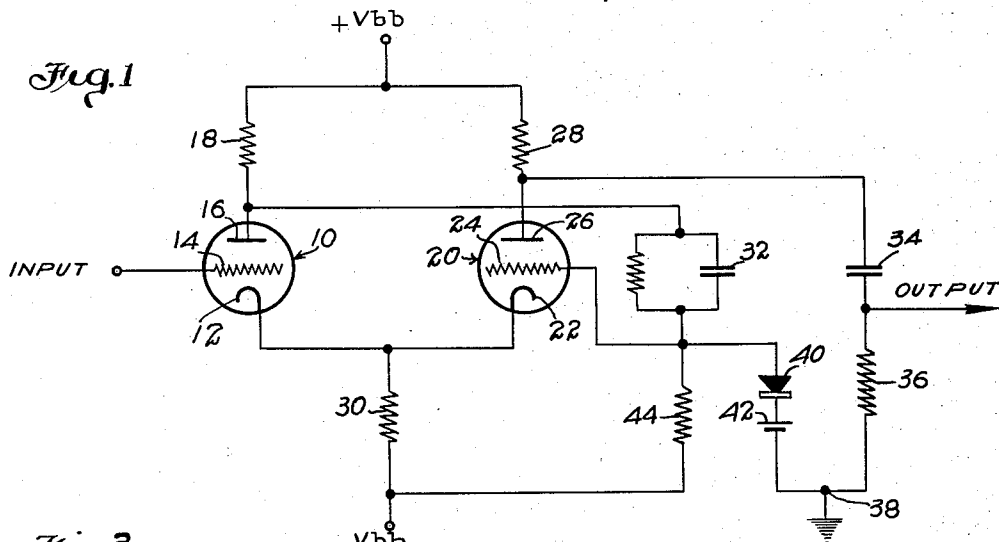
April 14, 1959

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2,882,400

TRIGGER CIRCUIT

Filed Oct. 17, 1955



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TRIGGER CIRCUIT

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Application October 17, 1955, Serial No. 540,814

4 Claims. (Cl. 250—27)

This invention relates to trigger circuits, and, more particularly, to improvements therein.

Trigger circuits consisting of two tubes with means for feedback connections between them are well known. One type of trigger circuit usually preferred for the type of operation wherein, in response to an input pulse the circuit must provide an output as long as the pulse is applied, having a good wave shape, is known commonly as the Schmitt trigger circuit. This type of trigger circuit has been described in an article entitled "A Thermionic Trigger," by O. H. Schmitt, in the Journal of Scientific Instruments, vol. 15, pp. 24-26, January 1938.

This trigger circuit usually consists of two tubes wherein the first tube has its anode coupled to the grid of the second tube and the two tubes have their cathodes connected to a common cathode load resistor. The second tube is usually biased to be conducting in the quiescent condition. When a pulse is applied to the first tube, the pulse must be of a sufficient amplitude to drive the first tube conducting, whereby the second tube is cut off and an extremely rectangular output which is somewhat amplified is derived. Where this trigger circuit is triggered with a positive pulse having a short rise time, the trigger action takes place very rapidly. Differentiation of the output from the second tube plate produces a positive pulse of high amplitude. However, if input pulses are applied to the trigger circuit which have a long rise time, the output of the second tube is deteriorated, and, when differentiated, produces a very small pulse which is very unsatisfactory. As a result, there is unreliable operation of devices which are to be driven by this differentiated output.

An object of the present invention is to provide an improved trigger circuit whereby the application of slow-rising pulses does not deteriorate the output obtained from the trigger circuit.

A further object of the present invention is the provision of an improved trigger circuit of the cathode-coupled-feedback type wherein the output is maintained substantially the same for a slow-rising pulse as it is for a fast-rising pulse.

A further object of the present invention is the provision of a novel, useful, and simple improved trigger circuit of the cathode-coupled-feedback type.

These and other features of the invention are achieved by coupling the cathode of the first tube of the trigger circuit to the common cathode resistance by a means such as a unilateral impedance which maintains the first-tube cathode decoupled from the second-tube cathode until such time as the first tube has attained a substantial state of conduction. At this time, the coupling between the two cathodes occurs. Also connected to the cathode of the first tube is a second unilateral impedance. This is connected to maintain the first-tube cathode potential substantially at ground until the decoupling action has terminated. In this manner, feedback between the first tube and the second tube via the common cathode load resistance does not function until the decoupling is ter-

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minated. At this time, substantially the full feedback action occurs, whereby output derived from the second tube is substantially as large when a slow-rising pulse is applied to the grid of the first tube as occurs when a fast-rising pulse is applied to the grid of the first tube. Thus, the performance of the trigger circuit remains substantially the same, regardless of the rise time of the pulses applied thereto.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a circuit diagram of a conventional trigger circuit of the Schmitt type;

Figure 2 shows wave shapes which are obtained upon the application of pulses having different rise times to the trigger circuit; also, there are shown wave shapes obtained at the output of the circuit;

Figure 3 is a circuit diagram of the embodiment of the invention; and

Figure 4 is a wave shape diagram showing the results obtained by using this invention.

Reference is now made to Figure 1. Therein is shown a trigger circuit of the cathode-coupled-feedback, or Schmitt, type. It comprises two tubes 10, 20. The first tube 10 has a cathode 12, a control grid 14, and an anode 16. The second tube 20 has a cathode 22, a control grid 24, and an anode 26. Each tube has a plate-load resistor 18, 28 which is connected between its anode and B+. A common cathode load resistor 30 is connected to both cathodes and to a source of negative potential. The anode of the first tube is connected through a network 32 to the grid of the second tube. Thus, there are two cross-coupling paths provided in the circuit; one is from the plate of the first tube to the grid of the second tube, and the second is via the common cathode load resistance.

A differentiating circuit consisting of a condenser 34 and a resistor 36 are connected between the plates of the second tube and the ground potential point 38. Output from the differentiating network is taken between the condenser and the resistor. In order to establish quiescent voltage levels of the grid and the cathode of the second tube which are essentially independent of reasonable variations in supply voltages, a diode 40 is connected from the grid 24 to a battery 42. The battery is connected to ground potential. A resistor is connected between the minus potential supply and the grid of the tube 20.

Referring now to Figure 2, when a voltage having the wave shaped as represented by the dotted line 42 is applied to the grid 14, a voltage wave shape as represented by the dotted line 44 is obtained at the cathode 12 of the first tube and a voltage wave shape as represented by the dotted line 46 is obtained at the plate of the second tube. The output which is obtained as a result of differentiating this voltage is shown by the dotted line 48. Thus, it may be seen that when the wave shape which is applied has a short rise time an output having a desired high amplitude is obtained. Thus, reliable operation of the following equipment is assured. However, when a voltage having a wave shape with a rise time which is relatively long, such as is represented by the wave shape 50, is applied to the grid of the first tube, the operation resulting is not at all satisfactory. A cathode voltage 52 is obtained at the cathode 12 of the first tube. It may be seen that this is not as abrupt or satisfactory as was previously obtained. The solid line 54 represents the wave shape of the voltage at the anode of the second tube. The result obtained when differentiating the output from

the anode of the second tube is represented by the wave shape 56. It may be seen that the amplitude of this is not nearly as large as the amplitude of the wave shape 48. Thus, the amplitude of the differentiated output varies considerably with the rise time of the pulses which are applied to the grid of the first tube.

The poor wave shapes are obtained because, as the input voltage to the grid of the first tube rises slowly into the conduction region of the first tube, the plate voltage of the second tube rises slowly because of the common cathode coupling across the cathode resistor 30. This slowly varying plate voltage does not develop an appreciable trigger voltage at the output of the differentiating circuit. By the time the conduction of the first tube becomes sufficiently great to have built up loop gain adequate for the high-speed flip-flop action to be developed, a major portion of the voltage swing at the output plate is expended by the ineffective slow-voltage change. Consequently, the voltage swing remaining for the high-speed flip-flop portion of the cycle may be inadequate to develop the required differentiated output.

The improvement provided by this invention is designed to circumvent the significant loss of positive trigger amplitude regardless of the rate at which the input voltage approaches the required triggering potential.

Reference is now made to Figure 3, which shows the embodiment of the invention. Only so much of the circuit of Figure 1 is shown as to establish the connections of the invention with the circuit shown in Figure 1. The fundamental problem involved here is that of preventing an appreciable change in plate current of the second tube until an adequate loop gain is established which can cause rapid flip-flop action to occur. In the improved circuit of this invention, there are included two diodes 60 and 62. Diode 60 is connected between the first tube cathode 12 and ground or a point of reference potential. Diode 62 is connected between the first-tube cathode 12 and the second-tube cathode 22, or, stated alternatively, is connected between the first-tube cathode and the common cathode load resistor 30. The function which these diodes perform is to insure that the plate current of the first tube, and, consequently, its transconductance and gain, are built up to reasonably large values without appreciably affecting the second-tube conduction. Initially, the first tube is cut off and the grid of the first tube is biased sufficiently negative so that no appreciable current will flow in either diode 60 or 62, because the two are essentially in series, and the diode 62 is biased in the reverse direction by the slightly positive cathode voltage of the second tube 20 as a result of the fact that it is conducting. The first-tube cathode voltage is essentially that of ground potential.

The description that follows will include the wave shapes of Figure 4, which are respectively those derived by the application of a fast-rise-time pulse represented by a dotted line, and those derived by the application of a slow-rise-time pulse, represented by a solid line. Let us first consider the operation with a slow-rise-time pulse. This has a wave shape which is represented, for example, by the solid line 64 (Figure 4). As this input voltage rises toward the cutoff potential value, the first tube will begin to conduct current as soon as cutoff potential (at time t_1) is attained. This result is achieved because diode 60 holds the cathode clamped essentially at ground potential and diode 62 is not conducting, since it is biased off. Therefore, the second cathode potential will have no effect on the first cathode at this time.

As the current in the first tube builds up, the plate voltage begins to drop. When this occurs, the effect of the positive bias applied to the grid of the second tube through the rectifier is reduced, which effect continues. However, at first as the clamp current begins to get less positive the second tube grid voltage remains essentially constant. However, as soon as the clamp current decreases to zero, the second grid begins to go negative,

and the cathode of the second tube follows it at a slightly more positive potential as dictated by the plate current vs. grid-voltage characteristics of the second tube. It is to be noted that a change of a few volts in the cathode of the second tube in the positive region has virtually no effect on the plate current of the second tube if the negative bias potential source is made relatively large (e.g. $V_{bb} = -150$ volts, as it usually is). Under these conditions, the current of the second tube at this time is determined almost exclusively by the constant parameters, such as the cathode resistor—the operating potentials applied to the tube. Therefore, although grid voltage is changing slightly, the plate voltage remains substantially constant.

The mode of operation of the circuit shifts abruptly at time t_3 , when the cathode voltage of the second tube tends to go more negative than the cathode voltage of the first tube. At that time, the diode 62 develops a high forward conductance which abruptly closes the regenerative loop, thereby initiating the fast flip-flop action. Since no appreciable portion of the available plate-voltage swing of the second tube had previously been expended at a nonfruitful slow rate, virtually the entire swing is available for the rapid transition at time t_3 , which is capable of developing full differentiated output voltage as represented by the curve 66. It is this full, positive differentiated output which is needed in many applications for reliable operation of following devices independently of the rate of rise of the input signal. Thus, the diodes that have been added serve the function of decoupling the cathode of the first tube from the cathode of the second tube for the time required for the first tube to go substantially conductive. At this time, the decoupling action is terminated.

The drive, which is then applied from the first tube through the cathode feedback path to the second tube, insures that its output is substantially the same output as would be obtained were a pulse having a fast rise time applied to the first-tube grid. Thus, the fast-rise-time pulse 68 provides at the plate of the second tube an output 70, which, when differentiated, will provide an output 72. A slow-rise-time pulse 64 provides an output at the plate of the second tube as represented by the solid line 65 and results in an output 66, which is substantially as great as the output 72.

Accordingly, there has been described and shown above a novel, useful improvement in a cathode-coupled trigger circuit whereby the output derived from the trigger circuit is substantially the same regardless of the duration of the rise time of the pulse applied to the input to the trigger circuit.

I claim:

1. In a trigger circuit of the type including a first and second tube, each having an anode, cathode, and control-grid electrode wherein the anode of the first tube is coupled to the grid of the second tube, and wherein the cathodes of said tubes are coupled to one end of a common cathode load resistor, and wherein a source of operating potential including a reference potential is applied to both tube anodes and the other end of said common cathode resistor, the improvement in said trigger circuit comprising means for maintaining said first-tube cathode decoupled from said second-tube cathode until said first tube has attained a condition of substantial current conduction, and means to maintain said first-tube cathode substantially at said reference potential value until said first-tube cathode is no longer decoupled from said second-tube cathode.

2. In a trigger circuit of the type including a first and second tube, each having an anode, cathode, and control-grid electrode wherein the anode of the first tube is coupled to the grid of the second tube and wherein the cathodes of said tubes are coupled to one end of a common cathode load resistor, wherein a source of operating potential including a point of ground potential is applied

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to both tube anodes and the other end of said common cathode load resistor, and wherein the second tube is biased to be conductive in the absence of an input above a predetermined voltage value to said first-tube grid, the improvement in said trigger circuit comprising a first unilateral impedance connected directly between said first-tube cathode and said point of ground potential, and a second unilateral impedance connected directly between said first-tube cathode and said common cathode load resistor.

3. In a trigger circuit of the type including a first and second tube, each having an anode, cathode, and control-grid electrode wherein the anode of the first tube is coupled to the grid of the second tube and wherein the cathodes of said tubes are coupled to one end of a common cathode load resistor, wherein a source of operating potential including a point of ground potential is applied to both tube anodes and the other end of said common cathode load resistor, and wherein the second tube is biased to be conductive in the absence of an input above a predetermined voltage value to said first-tube grid, the improvement in said trigger circuit comprising a first rectifier connected directly between said first-tube cathode and said point of reference potential, and a second rectifier connected directly between said first-tube cathode and said common cathode load resistor.

4. In a trigger circuit of the type including a first and

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second tube, each having an anode, cathode, and control-grid electrode wherein the anode of the first tube is coupled to the grid of the second tube and wherein the cathodes of said tubes are coupled to one end of a common cathode load resistor, wherein a source of operating potential including a point of ground potential is applied to both tube anodes and the other end of said common cathode load resistor, and wherein the second tube is biased to be conductive in the absence of an input above a predetermined voltage value to said first-tube grid, the improvement in said trigger circuit comprising a first rectifier having its anode coupled to said first-tube cathode and its cathode coupled to said point of ground potential, and a second rectifier having its anode coupled to said first-tube cathode and its cathode coupled to said common cathode load resistor.

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