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TRIGGERED PULSE GENERATOR

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Fig. 1.

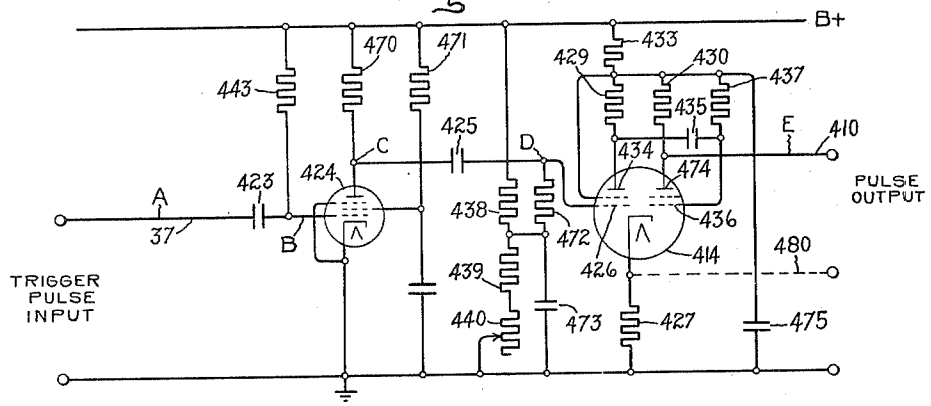
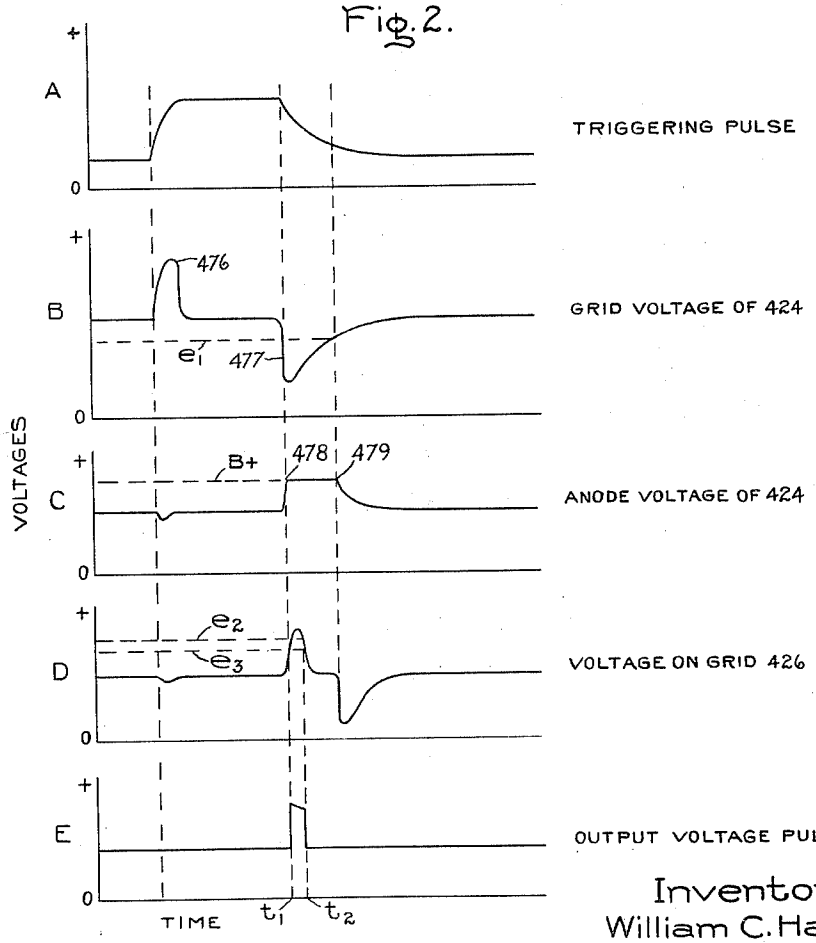


Fig. 2.



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TRIGGERED PULSE GENERATOR

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3 Claims. (Cl. 250—27)

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The present application is a division of my application Ser. No. 516,239, filed December 30, 1943, now U. S. Patent No. 2,467,208 assigned to the same assignee as the present application.

In the automatic range tracking circuits of pulse echo systems of the type illustrated in the above parent application, it is necessary to generate very short pulses, commonly known as aperture pulses. These short pulses may have a duration, or width, of from only a fraction of a microsecond up to several microseconds. They must be very accurately initiated in response to a train of applied synchronizing pulses or transients, and their duration and wave shape must be readily and precisely controllable. It is a primary object of the present invention to provide an improved pulse generator meeting these requirements.

Specifically, it is an object of the present invention to provide an improved pulse generator which may be very accurately triggered by applied pulses and which may be readily adjusted to produce extremely short pulses of substantially rectangular shape, and of an accurately controllable width which is not affected by the length of the triggering pulses.

It is a further object of the present invention to provide an improved triggered pulse generator which can be adjusted to produce extremely short pulses of less than one microsecond duration and which is not subject to false triggering even though the applied triggering transient may have a decay time, or discharge time constant, greater than the pulse duration.

For additional objects and advantages, and for a better understanding of the invention, attention is now directed to the following description and accompanying drawings, and also to the appended claims in which the features of the invention believed to be novel are particularly pointed out.

In the drawings:

Fig. 1 is a circuit diagram of one form of pulse generator embodying the invention; and

Fig. 2 graphically represents several voltage wave forms, appearing at various lettered points in the circuit of Fig. 1, on a common time scale.

The pulse generating apparatus of Fig. 1 comprises an electron discharge device 424, represented as a pentode, and a second electron discharge device 414 which is represented as including two separate tetrodes having a common cathode. Device 424 is utilized as a trigger amplifier and polarity reverser, and the two sections of device 414 are connected in a circuit resembling a known form of single-pulse generator or multivibrator, as will appear more fully from the description of the circuits and their operation below.

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The cathode of device 424 is connected directly to ground and a positive bias is impressed upon its control grid from a suitable source of operating potential, represented conventionally by a bus connected to B+, through a resistor 443. Suitable anode and screen grid operating potentials are also supplied from B+ through resistors 470 and 471 in conventional manner. The anode of device 424 is coupled to the left-hand control grid 426 of device 414 through a coupling capacitor 425. A potentiometer network, comprising resistors 438 and 439 and a variable resistor 440, is connected between the positive bus and ground. A bias potential is supplied to control grid 426 by a connection to the junction of resistors 438 and 439 through resistor 472. The lower end of resistor 472 is bypassed to ground through a capacitor 473.

A common cathode load resistor 427 is provided between the cathode of device 414 and ground. The left-hand and right-hand anodes 434 and 474 are respectively connected to the positive bus through individual resistors 429 and 430 and a common resistor 433. The right-hand control grid 436 is also connected to the positive bus through an individual resistor 437 and the common resistor 433. The upper end of resistor 437 is bypassed to ground through a capacitor 475. Control grid 436 is also coupled to anode 434 through a capacitor 435.

In operation, the trigger amplifier 424 is normally conducting by virtue of the relatively high positive bias supplied to its control grid. The bias on control grid 426 is adjusted with respect to the potential of anode 434 so that the left-hand section of device 414 is normally non-conducting. However, the control electrode 436 is positive with respect to the cathode and the right-hand section of the device 414 is normally conducting. The voltage drop thereby produced across the common cathode resistor 427 assists in maintaining the required negative bias upon control grid 426.

Assume now that a positive trigger pulse, as represented by curve A in Fig. 2, is applied through conductor 37 and a coupling capacitor 423 to the control grid of amplifier 424. The capacitor 423 and resistor 443 comprise a differentiating network having a predetermined time constant. Therefore the resultant pulse wave applied to the control grid of device 424 may, for example, be of the form illustrated by the curve B of Fig. 2. Since the device 424 is already conducting, the initial positive transient 476 does not change the conducting state of the amplifier.

However, at the beginning of the trailing edge of the A pulse wave, at time t_1, the sudden negative transient 477 applied to the control grid of device 424 drives the grid voltage below the cut-off value, represented by voltage e_1, thereby abruptly reducing the anode current to zero. The anode voltage of device 424 immediately rises substantially to the voltage B+ of the operating source, as represented at 478 in curve C. The anode voltage of device 424 remains at this value until point 479, when the transient 477 in the B pulse wave again rises above the cut off value e_1.

Capacitor 425 and associated resistors 438, 439, 440 and 476 comprise a differentiating circuit of relatively short time constant, with the result that the voltage applied to grid 426 has the shape represented by curve D in Fig. 2. The voltage level e_2 represents the value at which the left-hand section of device 414 is cut off. The left-hand section of device 414 now draws anode current and the potential of anode 434 drops abruptly, driving the control grid 436 of the right-hand section negative through capacitor 435. The anode current through the right-hand section of device 414 is thereby suddenly cut off, initiating the pulse wave at the anode 474 of the form shown by curve E in Fig. 2.

It will be recognized by those skilled in the art that the device 414 and associated circuits tend to operate as a single-pulse multivibrator in which capacitor 435 tends to recharge through a time constant network primarily comprising the capacitor 435 and resistor 437, so that at the end of a predetermined time the right-hand section of device 414 would again begin to draw anode current and restore the initial operating conditions. However, it is important that the time constant of this multivibrator be adjusted so as to be relatively long compared to the desired output pulse duration. The time constant of the network associated with capacitor 425, which primarily consists of resistor 470, capacitor 425 and resistor 472, is arranged to be very much shorter than the natural pulse period of the multivibrator, and thereby the time constant of this network determines the length of the E pulse in the following manner.

The E pulse is terminated when capacitor 425 charges enough to drive the control grid 426 sufficiently negative to cause the right-hand section of device 414 again to become conducting. This corresponds to a voltage level e_3 on curve D in Fig. 2. This terminates the E pulse at time t_2. The length of the charging period required to cause control grid 426 to reach this potential may be varied by adjustment of resistor 440.

The right-hand section of device 414 preferably passes a larger current through cathode resistor 427 than does the left-hand section, when conducting, which means that the potential on resistor 427 increases during the E pulse. Therefore, the pulse output may optionally be taken from this resistor, as indicated by the dashed connection 480 in Fig. 1.

It will be observed from Fig. 2 that the length of the triggering transient 478 is also relatively great with respect to the width of the E pulse. In other words, the E pulse also has a duration shorter than the time constant of the differentiating network comprising capacitor 423 and resistor 443. Consequently, although the capacitor 423 begins to charge upon the initiation of the E pulse, the discharge device 424 not only remains cut off throughout the E pulse period but until point 479 in curve C.

It will thus be apparent that the E pulse may be made of extremely short duration, determined primarily by the time constant of the coupling network between the trigger amplifier and the multivibrator circuit, even though the trailing edge of the incoming trigger pulse may have an appreciable "tail" both before and after differentiation. This is a distinct advantage over prior art circuits of the type in which a single-pulse generator is triggered directly by means of such a transient, because the maintenance of the transient voltage for a period longer than the duration of the desired pulse will normally tend to produce a false retriggering of a multivibrator.

While the present invention has been described as having particular utility in a pulse echo system of the type disclosed in the parent application referred to above, it will of course be obvious that it has general application to a triggered pulse generator wherever extremely short pulses of substantially rectangular wave form are required. It has been found in actual practice that pulses having a duration as low as ¼-microsecond or less may readily be produced.

While a particular embodiment of the invention has been shown and described, it will of course be understood that various modifications may be made without departing from the invention. The appended claims are therefore intended to cover any such modifications within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a pair of discharge devices connected as a multivibrator, means to reverse the current conditions in said devices in response to a voltage transient having a predetermined period, said means including an electron discharge device having an anode, a cathode and control electrode, a condenser connected between said anode and said multivibrator, means to supply said transient between said control electrode and cathode to reverse the current conditions in said first two devices upon initiation of said transient, and means to produce an opposite reversal of said current conditions at a time thereafter determined by said condenser and independent of and shorter than the period of said transient.

2. A triggered pulse generator for generating short pulses of substantially rectangular shape comprising, in combination, a pair of electron discharge devices connected in a feedback circuit so that one of said devices is normally rendered non-conductive while the other is conductive, a third, normally conductive electron discharge device having a control grid and an anode, an anode load resistor connected in circuit with said anode, means for impressing a negative transient on said control grid through a resistance-capacitance differentiating network having a time constant which is relatively long as compared to the desired duration of said pulses, said third device being rendered abruptly non-conductive by said transient for an interval longer than said desired pulse duration, a second resistance-capacitance differentiating network including said anode resistor and a coupling capacitor, said second network having a relatively short time constant as compared to that of said first network, and means for impressing voltage through said capacitor on said one device in a sense to render it non-conducting, said one device remaining non-conductive for a pulse pe-

riod determined by the time constant of said second network and independent of the duration of said transient.

3. A triggered pulse generator comprising, in combination, a pair of electron discharge devices connected in a single-pulse multivibrator circuit, said circuit being responsive to a triggering impulse supplied to one of said devices to initiate a single pulse of substantially rectangular waveform and of a normal duration determined by the time constant of a resistance-capacitance network in said circuit, a third, normally-conductive electron discharge device having an anode load resistor, a second resistance-capacitance network comprising said resistor for supplying triggering potentials from said third device to said one device, said second network having a substantially shorter time constant than said first network, means for abruptly rendering said third device non-conductive for a

time interval at least as long as that corresponding to the time constant of said second network, thereby to initiate said pulse, and means comprising said second network for terminating said pulse after a time interval substantially shorter than said normal duration.

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