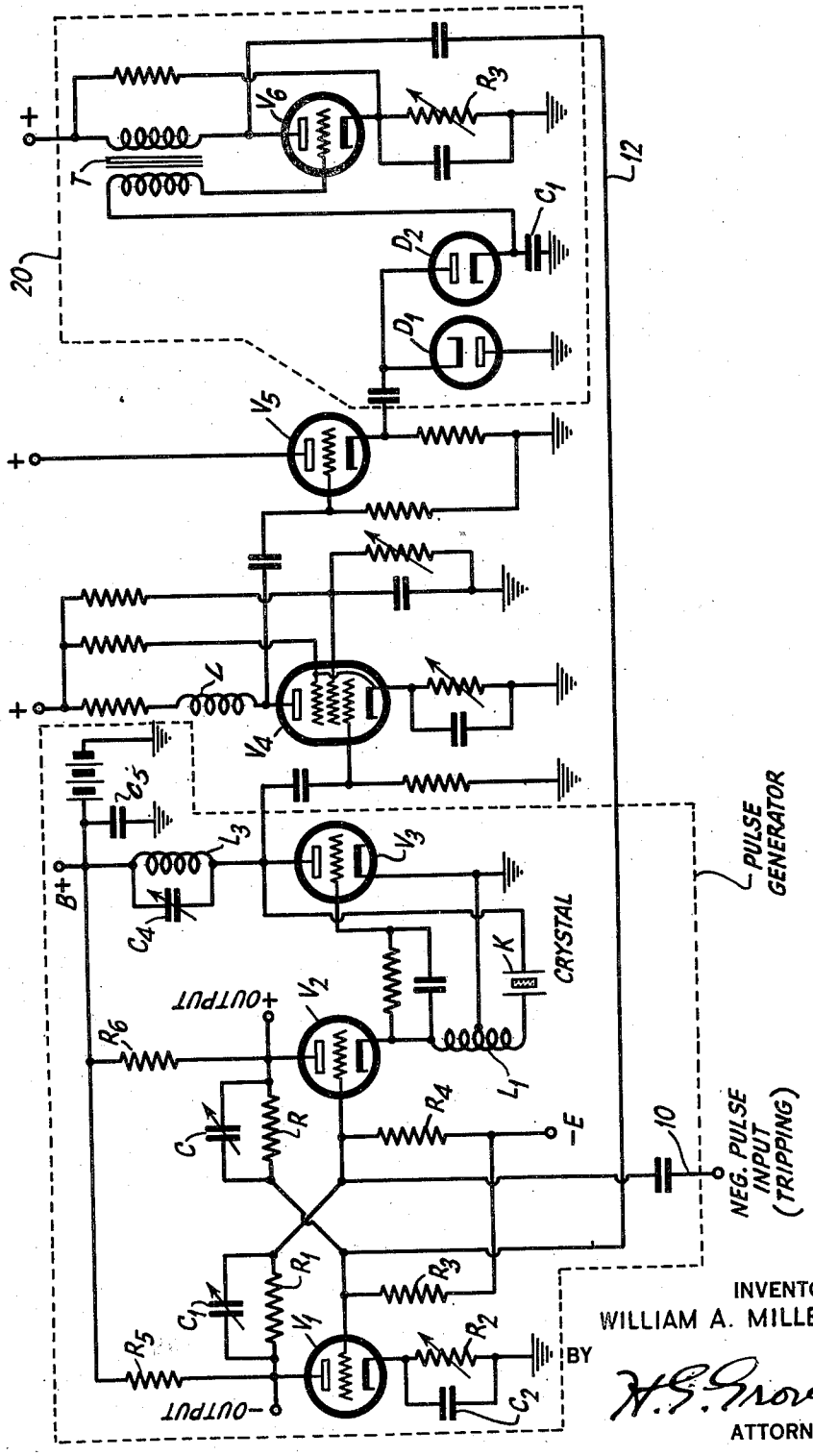
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PULSE GENERATOR SYSTEM

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PULSE GENERATOR SYSTEM

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The present invention provides a method of and apparatus for generating equal duration or width rectangular wave pulses having a width of a high degree of accuracy.

The system of the invention provides a pulse whose width or duration may be varied by the operator or attendant, but once a particular width has been chosen, this width is controlled by a crystal-controlled oscillation generator. Thus, the precision of the maintenance of the constant width of the generated pulse is the precision to which a crystal can be made to operate.

A more detailed description of the invention follows, in conjunction with a drawing whose single figure illustrates an embodiment of the invention.

Referring to the drawing, there is shown a trigger circuit comprising vacuum tubes V1 and V2 whose anodes and grids are interconnected regeneratively so as to have two degrees of stability or freedom. The grid of tube V1 is connected to the anode of tube V2 through a connection including a resistor R shunted by condenser C, while the grid of tube V2 is connected to the anode of tube V1 through a resistor R1 shunted by a condenser C1. The grids are also connected to the negative terminal —E of a source of bias potential through individual resistors R3 and R4. In the cathode circuit of the tube V1, there is provided a variable resistor R2 shunted by a condenser C2. The lower end of resistor R2 is connected to ground as shown. The anodes of tubes V1 and V2 are connected to the positive terminal B+ of a source of unidirectional anode polarizing potentials through individual anode resistors R5 and R6. Input pulses of negative polarity for tripping the trigger circuit are supplied through lead 10. In the cathode circuit of the tube V2, there is provided the frequency determining portion of a radio frequency oscillator V3 which will be described later.

The bias applied to tube V1 by means of the resistor R2 may be, but need not be, sufficient to cut-off tube V1 since, due to the feedback coupling between the tubes V1 and V2, it is only necessary to insure the fact that tube V1 is cut-off before the application of the first tripping pulse to input lead 10; that is, to assure that tube V1 draws less current than tube V2 when power is first applied to the electrodes of the trigger circuit. The bias —E assures that the potential of the grids of tubes V1 and V2 drops below ground. It has been assumed that tube V1 is identical with V2 but if such identity does not exist, a slight adjustment of resistor R2 is sufficient to insure the cut-off of tube V1 before the application of the first tripping pulse.

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The trigger circuit V1, V2 is in the nature of a locking circuit. Putting it in other words, it has two degrees of stability and does not act like a free running multivibrator. This trigger circuit, as shown, requires a tripping pulse to turn on tube V1 and to turn off tube V2, and a second tripping pulse over lead 12 to turn off tube V1 and to turn on tube V2. More specifically, if, initially, V1 is non-conductive and tube V2 conductive, these tubes will remain in this condition until a negative tripping pulse is applied to lead 10. The application of a negative tripping pulse to lead 10 will cause tube V1 to become conductive and tube V2 to become non-conductive. These tubes will then remain in this condition of stability until another negative pulse is applied to lead 12. The application of this second negative pulse to lead 12 will cause tube V1 to become non-conductive and tube V2 to become conductive, and the tubes will remain in this new condition of stability until another input tripping pulse is applied to lead 10.

In the cathode circuit of tube V2 of the trigger circuit, there is provided the main tank of an oscillation generator connected as a Hartley oscillator. This main tank includes the inductance L1 and a crystal K. The crystal K is connected between one terminal of the inductance L1 and the anode of a tube V3. The cathode of tube V3 is connected to ground and to an intermediate point on inductance L1. The grid of tube V3 is connected through a resistance-shunt condenser combination to the other terminal of the inductance L1 which last terminal is directly connected to the cathode of tube V2. The anode of tube V3 is also connected through a parallel tuned circuit L3, C4 to the positive terminal B+ of the anode supply. A bypass condenser C5 provides a low A. C. impedance to ground, thus preventing interaction or feed back from one tube to the other. Tuned circuit L3, C4 has some, but substantially little, effect upon the frequency of oscillation of the radio frequency oscillator V3.

When tube V2 of the trigger circuit is conducting, it provides a low resistance shunt path to ground for the main tank circuit of the oscillator V3 and prevents the radio frequency oscillation generator from oscillating. Stated otherwise, as long as tube V2 conducts, it keeps the grid-cathode circuit of tube V3 shunted to ground by the circuit comprising tube V2 and condenser C5. Since the grid of tube V3 is effectively at zero radio frequency potential, the oscillator is kept

in a non-oscillatory condition. As soon as tube V2 is cut-off (becomes non-conducting) tube V3 will then oscillate at a frequency controlled by the crystal K.

The system so far described, which includes the trigger circuit V1, V2 and the oscillator tube V3 with its associated elements, is substantially the same which is described in Fig. 3 of my copending application, Serial No. 688,742, filed August 6, 1946.

The output of the oscillator V3 which comprises sine wave trains interrupted or pulsed by the trigger circuit V1, V2, is fed to the first grid of a limiter tube V4. Limiter tube V4 has in circuit with its anode a network including an inductance L for enabling wide band compensation. The limiter V4 assures the squaring of each negative half-cycle applied thereto by the oscillator (by clipping action due to overdriving the grid) and amplifies the same before applying it through the impedance changer tube V5 to the counter 20. Stated in other words, the tube V4 and its associated circuits may be described as a clipper circuit which makes use of an over-driven shunt-compensated amplifier. The term "wide band compensation" means that the tube V4 has an inductance in its anode which compensates for the degeneration of the high frequency components of the output pulse which is due to the finite size of the output capacitance of tube V4 and the unavoidable stray wire capacitance. Tube V5, in effect, is a cathode follower and assures a low impedance coupling between the limiter tube V4 and the counter 20.

The counter 20 is illustrative of any suitable counting circuit. In the form shown, it is a blocking oscillator counter well known in the television art, and comprises a counter control resistor R3 in the cathode circuit of a vacuum tube V6. The anode and grid of tube V6 are connected to different windings of a pulse transformer T. The input to the counter V6 from the cathode follower tube V5 includes one winding of the transformer tube and a pair of oppositely connected diodes D1 and D2. A charging condenser C1 is shown in circuit with the cathode of D2 and the grid of tube V6. The diodes D1 and D2 assure unipotential charging of the condenser C1 with each positive pulse applied thereto from the cathode follower. When a sufficient number of positive pulses are applied to condenser C1 to build up a voltage there across sufficiently large to overcome the cut-off bias on tube V6 produced by resistor R3, the tube V6 will suddenly conduct, drawing grid current which discharges condenser C1 and returns condenser C1 to the initial state of charge in readiness for counting again. When tube V6 of the counter conducts, a negative pulse is applied to lead 12 which is connected to the grid of tube V1. This negative pulse on lead 12 causes the trigger circuit V1, V2, to return to the initial state of equilibrium in which the tube V1 is non-conductive and tube V2 is conductive. The trigger circuit will remain in this restored or initial state until another negative pulse is applied to the tripping input terminal 10.

By means of the present invention, I have been able to obtain a precision or accuracy in the width or duration of the rectangular wave output from the trigger circuit V1, V2 which cannot be obtained by conventional circuits. As an illustration, if the crystal K is used at a fundamental frequency of one megacycle with a frequency stability of ±1 part in 10,000,000 and the counter 20 is adjusted to count 5 pulses, then the pulse obtained from the output terminals of the trigger circuit V1, V2, will have a width or duration of 5 microseconds with a relative accuracy of ±1 part in 10,000,000. The absolute accuracy of the system without calibration, might be somewhat less than this due to the finite build-up times of the oscillator circuit and the counter. However, this error can be determined and suitable corrections made.

The trigger circuit V1, V2 is shown provided with two output terminals; namely, a negative pulse output terminal connected directly to the anode of tube V1, and a positive output terminal connected to the anode of tube V2. Obviously, the electrode structures of tubes V1 and V2 may be located within a single evacuated envelope.

When longer duration pulses are employed than the 5 microseconds in the above mentioned example, more counters may be added or a lower frequency crystal K may be used, or both. Where longer duration pulses are required, simplification of the system of the invention may be employed by removing the wide band compensation element L of the limiter V4 and also the eliminating of the cathode follower V5.

The system of the invention is not limited to using negative pulses to trip the trigger circuit, because positive tripping pulses can be used to give the same results merely by connecting lead 10 to the grid of tube V1 and connecting lead 12 to the grid of tube V2.

What is claimed is:

1. The combination with a trigger circuit having two degrees of electrical stability and comprising a pair of regeneratively coupled vacuum tube devices, whereby one device is conductive when the other is non-conductive, and vice versa, and the change-over from one conduction state to the other is made only in response to a tripping input pulse, of a highly stable oscillator comprising a vacuum tube having a grid and a cathode and a grid-cathode circuit, said oscillator being connected to said trigger circuit with the grid-cathode circuit of the oscillator effectively shunted by one of said devices whenever said one of said devices is conductive, a counter coupled to the output of said oscillator to count the oscillations thereof and connected to said trigger circuit to apply a tripping pulse thereto after a predetermined number of said oscillations, and means for supplying an initiating input tripping pulse to said trigger circuit to make the other of said devices conductive.

2. In combination with a trigger circuit having two degrees of electrical stability and comprising a pair of regeneratively coupled space discharge tubes each of which is conductive to the exclusion of the other and in which trigger circuit the conduction in a first of said pair of tubes is to be controlled to last a predetermined period of time after an initiating impulse applied to said circuit which impulse causes said first tube to become conductive and the second of said tubes to become non-conductive, an oscillation circuit having a tank circuit connected with a portion thereof shunted by the space discharge path of said second tube to prevent oscillations thereof during conduction of said second tube, a limiter coupled to said oscillator circuit, a counter circuit connected to said limiter to count the output waves from said limiter and to produce an output pulse after a predetermined number of said oscillations, and means to apply said output pulse to said trigger circuit to cause said second tube to conduct to terminate conduction in said first

tube and to again initiate conduction in said second tube to halt said oscillations, whereby the period of conduction of said first tube is determined by the frequency of said oscillations and by the said predetermined number of oscillations thereof.

3. The combination claimed in claim 2, each of said pair of tubes being a vacuum tube.

4. The combination claimed in claim 2, said oscillator being a crystal controlled oscillator.

5. The combination claimed in claim 2, said counter circuit comprising a blocking oscillator.

6. The combination claimed in claim 2, said counter circuit comprising a blocking oscillator the oscillation of which provides said output pulse.

7. The combination claimed in claim 2, said tank circuit comprising an inductance, a portion of which is shunted by the space discharge path of said second tube.

8. The combination claimed in claim 2, said means to apply said output pulse to said counter circuit comprising a cathode follower.

9. The combination with a trigger circuit having two degrees of electrical stability and comprising a pair of regeneratively coupled vacuum tube devices, whereby one device is conductive when the other is non-conductive, and vice versa, and the change-over from one conduction state to the other is made only in response to a tripping input pulse, of a highly stable oscillator comprising a vacuum tube having a grid and a cathode and a grid-cathode circuit, said oscillator being connected to said trigger circuit with the grid-cathode circuit of the oscillator effectively shunted by one of said devices whenever solely one of said devices is conductive, a limiter tube coupled to the output of said oscillator for squaring each negative half cycle applied thereto by the oscillator, a network including an inductance in the anode circuit of said limiter, a cathode follower coupled to the output of said limiter, a counter coupled to said cathode follower, a connection from said counter to the other device of said trigger circuit for applying a negative pulse to said trigger circuit whenever said counter completes a count, and means for supplying an initiating input tripping pulse to said trigger circuit to make said other device conductive.

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