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P. R. BELL, JR  
PULSE SHAPING CIRCUIT

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FIG. 1

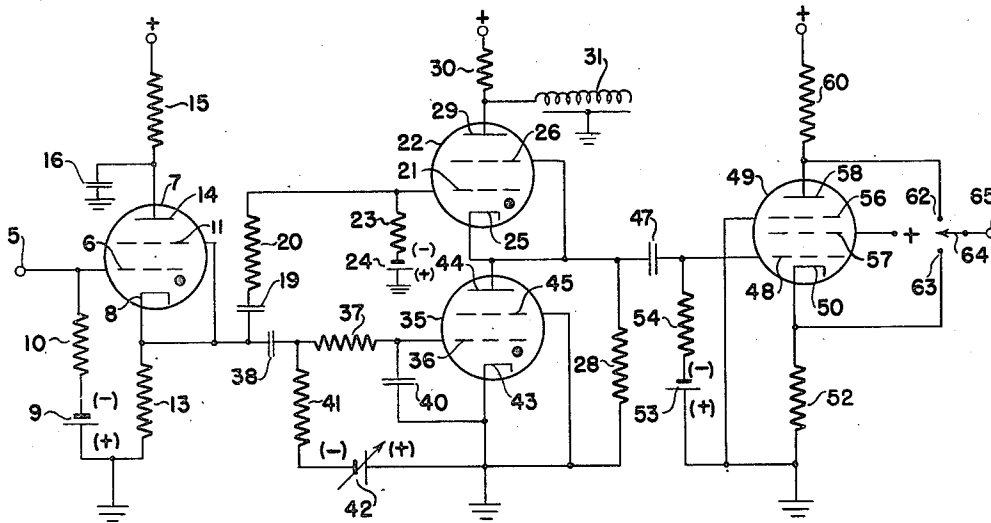
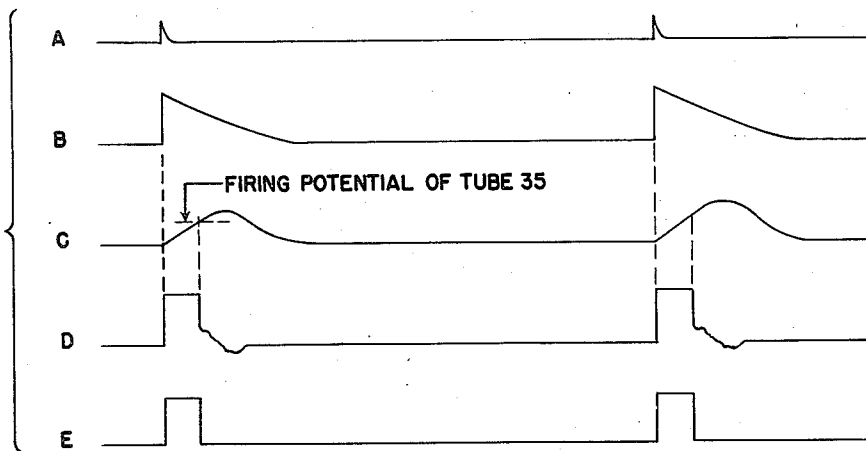


FIG. 2



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## UNITED STATES PATENT OFFICE

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## PULSE SHAPING CIRCUIT

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America as represented by the Secretary of War

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2 Claims. (Cl. 250-27)

1

This invention relates in general to electrical circuits and more particularly to those circuits which are adapted for production of short, accurately shaped voltage pulses.

In many applications of electrical circuits it is desirable to have periodic voltage pulses which are rectangular in form and have extremely steep sides. Due to the high harmonic content of such a wave, one application to which it may be put is in the testing of amplifier band pass characteristics. Another use is in the determination of phase distortions in amplifier stages. For such applications, a wave must be a close approximation to an idealized rectangular wave shape. It is also advantageous to have the width of the generated pulses continuously variable.

Accordingly, it is one object of my invention to provide a circuit capable of generating a rectangular voltage wave.

Another object is to provide a rectangular voltage wave having an extremely fast time of rise and fall.

Still another object is to provide a means for generating a series of variable width voltage pulses.

These and further objects of the invention will be apparent to those skilled in the art upon reference to the following specification, claims, and to the drawings in which:

Fig. 1 is a schematic diagram of one embodiment of the present invention; and,

Fig. 2 is a compilation of voltage waveforms present at various points in the circuit shown in Fig. 1.

The invention uses several grid-controlled gaseous rectifier tubes, the firing of which is controlled by a single trigger to shape a narrow, rectangular voltage pulse. The circuit can be triggered by a periodic wave so that a train of rectangular waves of any desired frequency of recurrence may be generated.

Referring now to Fig. 1, input terminal 5 is connected to grid 6 of a grid-controlled gaseous rectifier tube 7 of a type which will be hereinafter referred to as a Thyatron. Control grid 6 is biased negatively with respect to cathode 8 by a suitable source of potential 9 which is connected in series with resistor 10 between grid 6 and ground. Cathode 8 is also connected through cathode load resistor 13 to a point of ground potential. Anode 14 is biased positively through resistor 15 and capacitor 16 is connected from anode 14 to ground.

Connection is made from cathode 8 through capacitor 19 and resistor 20 to control grid 21 of

2

another Thyatron tube 22. Grid 21 is connected through resistor 23 and bias source 24 to ground. Resistor 28 is connected from cathode 25 to ground and suppressor grid 26 is tied to cathode 25. A delay line 31 of good phase characteristics and of high characteristic impedance is connected to anode 29 which is biased positively through resistor 30.

A third Thyatron 35 is connected across resistor 28, control grid 36 being connected through resistor 37 and capacitor 38 to cathode 8 of Thyatron 7. Capacitor 40 is connected from grid 36 to ground and resistor 41 and variable bias source 42 are connected in series from the junction of capacitor 38 and resistor 37 to a point of ground potential. Cathode 43 of Thyatron 35 is connected directly to ground and anode 44 is connected to cathode 25 of Thyatron 22. Suppressor grid 45 is connected directly to ground.

Voltages appearing across resistor 28 are impressed through capacitor 47 onto control grid 48 of vacuum tube 49, cathode 50 of which is connected through resistor 52 to ground. Grid 48 is held below cutoff potential with respect to cathode 50 by bias source 53 which is connected in series with resistor 54 between grid 48 and ground. Suppressor grid 55 of tube 49 is also grounded, while screen grid 57 is biased positively. Anode 58 is connected through load resistor 60 to a suitable source of positive potential. To increase the flexibility of the circuit terminals 62 and 63 are brought out from anode 58 and cathode 59, respectively, switch 64 being employed to connect either of the terminals to output terminal 65.

In operation of the circuit, all tubes are normally non-conducting, being maintained in that state by the negative bias applied to the control grid of each. A trigger pulse of positive polarity and of sufficient amplitude to overcome the negative bias on grid 6 of Thyatron 7 is applied to input terminal 5. When grid 6 is raised above cutoff potential with respect to cathode 8, Thyatron 7 will pass a high value of current almost instantaneously, generating a sudden rise of potential across cathode load resistor 13. As is well known in the art, once conduction has been established in a gaseous tube, the grid loses control and conduction must be stopped by lowering the anode-cathode potential. This is accomplished by connecting capacitor 16 from anode 14 to ground. Before Thyatron 7 fires, capacitor 16 is allowed to charge through resistor 15, acquiring a voltage of the order of that of the positive bias supply. When Thyatron 7 fires, capac-

3

itor 16 tends to discharge through tube 7 and resistor 13. However, the time constant of the discharge path is sufficiently long so that capacitor 15 supplies anode voltage for tube 7 for a length of time which is greater than the duration of the desired output pulse from the circuit.

When capacitor 16 has discharged to a point where the voltage across it is insufficient to maintain conduction in tube 7, current flow through the tube will cease and grid 6 will regain control. Capacitor 16 then charges through resistor 15 in preparation for another cycle of operation. It is characteristic of Thyratron tubes that current through them reaches its maximum value almost instantaneously upon firing, although cessation of conduction may be somewhat irregular due to the lowering of anode potential. Hence, throughout the present invention initiation of current flow is used for pulse shaping.

The roughly exponential voltage pulse which is generated across resistor 13 is applied through coupling capacitor 19 and resistor 20 to grid 21 of a second Thyratron 22. Thyratron 22 is fired by the leading edge of the applied voltage pulse and a sharp rise in voltage occurs across resistor 28. Delay line 31 connected to anode 29 serves a purpose analogous to that of capacitor 16. The delay line illustrated is one consisting of a coil having many turns of wire with a high distributed capacitance. However, it will be understood that certain other types will perform as satisfactorily in this connection.

Voltages existing across resistor 13 are also applied through coupling capacitor 38 to the series combination of resistor 37 and capacitor 40. The time constant of this combination is quite long so that the rise of voltage across capacitor 40 over the period of application of a pulse from resistor 13 is essentially linear. The voltage across capacitor 40 is applied between grid 36 and cathode 43 of Thyratron 35. When a pulse is applied to resistor 37 and capacitor 40, the potential on grid 36 will increase until the negative bias is overcome and Thyratron 35 fires, the time delay between application of a pulse and firing being determined by the amount of bias furnished from variable source 42. When tube 35 fires, resistor 28 is effectively short circuited by reason of the low voltage drop across a conducting Thyratron.

Therefore, there is generated across resistor 28 a short voltage pulse with a quick time of rise and fall. However, it has been found that irregularities are sometimes present in the pulse, hence a limiter amplifier stage is employed. Tube 49 is normally biased considerably beyond cutoff. When Thyratron 22 is triggered on, the voltage rise across resistor 28 is sufficient to raise grid 48 in tube 49 to the point where it draws current. Delay line 31 maintains the anode voltage on Thyratron 22 substantially constant, being superior to capacitor 16 in this respect. It has been found that there will often be a slight ripple on the tops of the pulses generated across resistor 28. By driving grid 48 positive this ripple is eliminated from the output pulses. Moreover, when Thyratron 35 fires, the voltage across resistor 28 drops sharply at first and then somewhat irregularly. Adjustment of the bias level on grid 48 will bring the trailing edge irregularities below the cutoff potential so that they are not passed by the limiter amplifier stage. The amplifier tube is loaded both in the plate and in the cathode circuits. Hence, pulses of substan-

4

tially the same shape but of opposite polarity will appear at anode 58 and cathode 50. Switch 64 is used to select which type of pulse will be applied to output terminal 65.

It is not unusual to obtain with this circuit pulses having a time of rise of 0.01 microsecond, a time of fall of 0.01 microsecond or less, and a width variable from 0.05 to 1.0 microsecond or more, the maximum width being substantially equal to twice the delay time of delay line 31.

Some of the voltage conditions which have been described hereinabove are shown in Fig. 2, in which curve A represents slightly over one cycle of the periodic trigger pulse to input terminal 5, curve B represents the voltage appearing across resistor 13, curve C is the potential across capacitor 40, and curve D is the pulse generated across resistor 28. Curve C is drawn to indicate the maximum range over which the potential applied to grid 36 may vary although firing of tube 35 will alter its shape somewhat. It will be noted that the trailing edges of the pulses shown in curve D depart from the shape which it is desired to obtain. However, due to the action of the limiter amplifier only the upper portion of each pulse is amplified resulting in output pulses as shown in curve E which represents the voltage at terminal 63.

Apart from the exceptionally swift rise and fall of the pulses generated, my circuit also affords the advantage of producing pulses which are quite flat-topped. Moreover the operation of the circuit is relatively independent of variations in the nature of the input trigger voltage, which make it highly stable.

While there has been described hereinabove what is at present considered to be a preferred embodiment of the present invention, it will be obvious to those skilled in the art that changes and modifications may be made therein without exercise of inventive ingenuity. Hence, I claim all such modifications and adaptations as may fall fairly within the spirit and scope of the herein-after appended claims.

What I claim is:

1. An electrical circuit for generating voltage pulses substantially rectangular in shape and of variable duration comprising a first grid-controlled gaseous rectifier electron tube having anode, cathode, control, and suppressor electrodes, an energy storage device connected to said anode electrode, impedance means connected in the cathode-ground circuit of said first electron tube, means to apply a triggering pulse to the grid of said first electron tube for initiating current flow in said first electron tube whereby a voltage is developed across said impedance means, the duration of said conduction being dependent on the amount of energy stored in said energy storage device; a second grid-controlled multi-grid gaseous rectifier electron tube, a delay line energy storage device connected to the anode electrode of said second electron tube, a second impedance means connected in the cathode-ground circuit of said second electron tube, means for impressing voltage developed across said first impedance means onto the control electrode of said second electron tube to cause conduction in said tube; a third multi-grid gaseous electron tube, means for connecting the space discharge path of said third electron tube in parallel with said second impedance means, resistance-capacitance delay means connected to the control electrode of said third electron tube, means for impressing

5

voltages developed across said first impedance means onto said resistance-capacitance delay means so that conduction in said third electron tube is delayed behind conduction in said second electron tube a predetermined amount of time; a fourth electron tube having at least anode, cathode, and control electrodes, means for impressing voltages developed across said second impedance means onto the control electrode of said fourth electron tube so that at least a portion of said voltages is amplified by said fourth electron tube, and means for deriving an output from said fourth electron tube.

2. An electrical circuit for generating voltage pulses of steep wave front and steep trailing edge comprising first and second grid controlled gaseous electron tubes each having an anode-cathode circuit and a control electrode, an energy storage device connected to the anode-cathode circuit of said first tube in series with an impedance, means to charge said storage device, means to apply a triggering pulse to the control electrode of said first tube for initiating current flow therein, whereby a steep wave-front voltage is developed across said impedance,

6

means for connecting the anode cathode circuit of said second tube in parallel with said impedance, means to apply said triggering pulse to the grid of said second electron tube through a delay means for initiating current flow in said second electron tube, whereby said voltage developed across said impedance is terminated in a steep trailing edge and said storage device is discharged.

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