

Aug. 17, 1948.

W. A. MILLER

2,447,082

GENERATOR CIRCUIT

Filed June 29, 1944

2 Sheets-Sheet 1

Fig. 1.

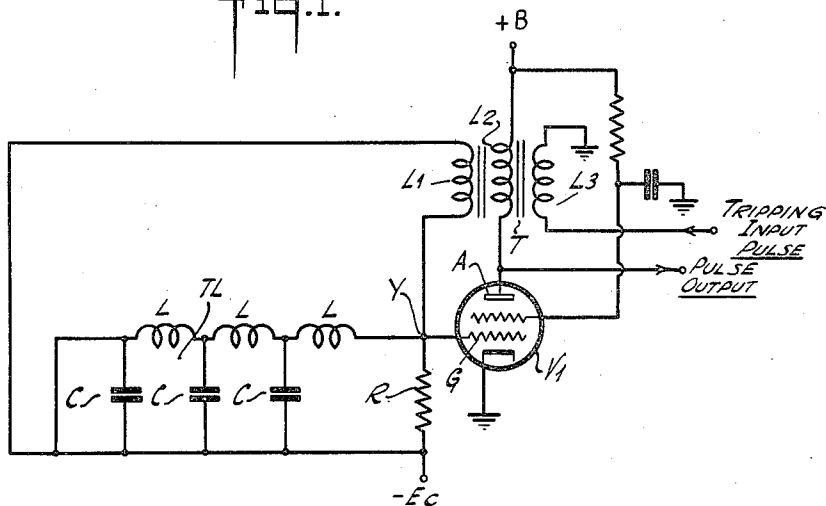
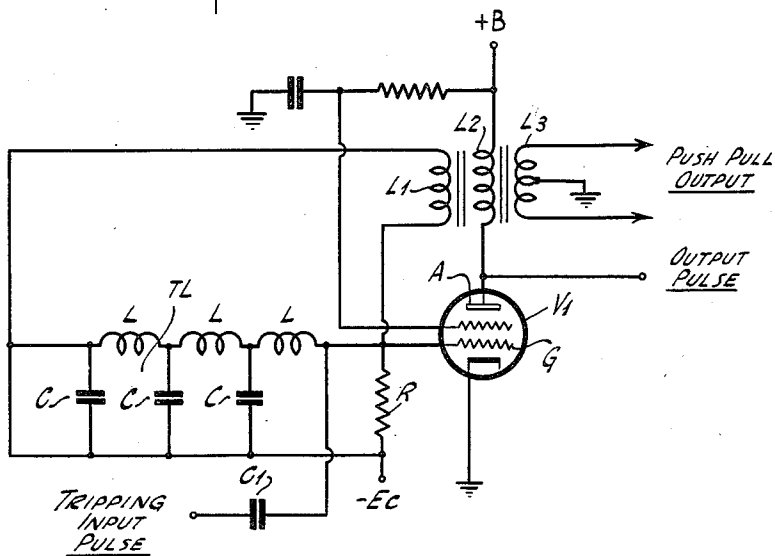


Fig. 2.



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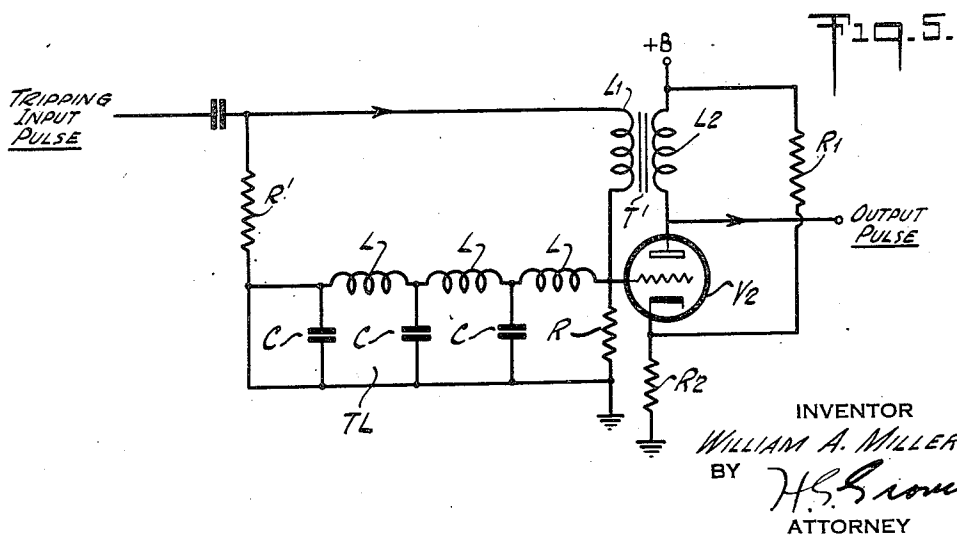
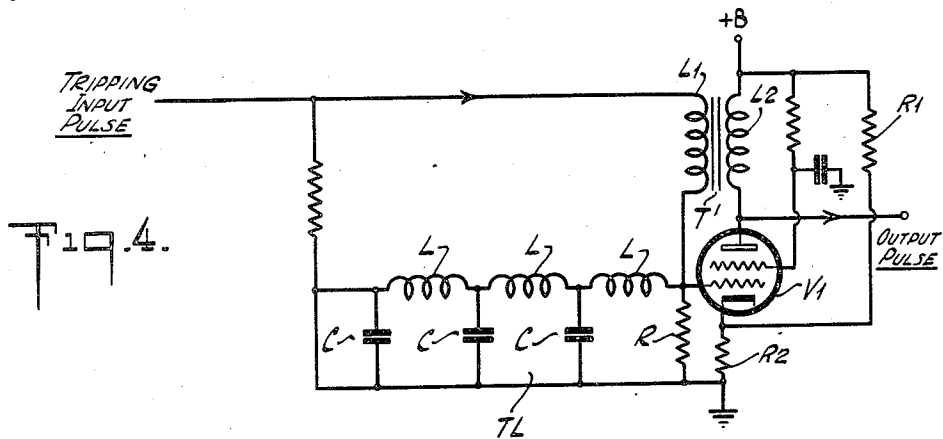
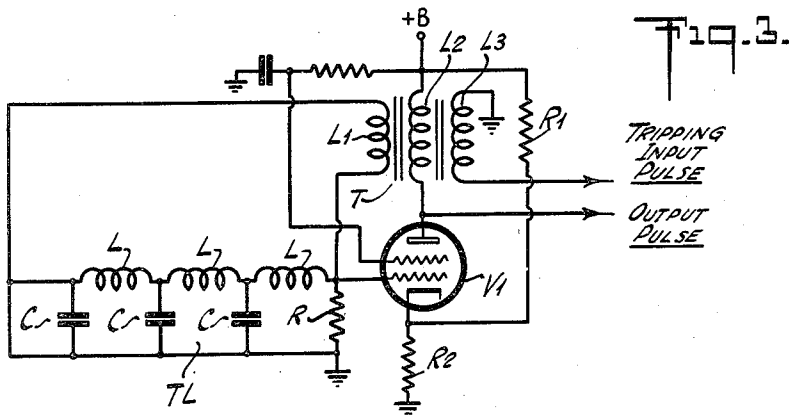
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2 Sheets-Sheet 2



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2,447,082

GENERATOR CIRCUIT

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Application June 29, 1944, Serial No. 542,706

11 Claims. (Cl. 250—36)

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This invention relates to pulse generator circuits.

An object of the present invention is to provide a generator capable of producing pulses of fixed width and of a time duration which is controlled by the characteristics of a transmission line, and whose repetition rate is controlled by and synchronized with a driving source of pulses which need not have a constant recurrence rate.

Another object is to provide a line-controlled biased blocking oscillator which employs a single vacuum tube and is of simple construction.

In brief, the present invention comprises a vacuum tube blocking oscillator which is normally biased to the anode current cut-off condition and is controlled by an external source of pulses either of random or constant repetition rate, to thereby produce a corresponding number of output pulses which are of fixed width. A transmission line is employed to accurately control the time duration (width) of each pulse generated by the blocking oscillator. This transmission line may have lumped sections, such as an artificial line, or may be a coaxial line of the proper length, and may be spirally wound in the interest of compactness. The characteristics of the line are suitably chosen to provide a desired time delay for a wave traversing its length.

A more detailed description of the invention follows in conjunction with a drawing, wherein Figs. 1 to 5 illustrate different embodiments of the line-controlled pulse generator of the invention. Throughout these figures, the same reference letters are used to designate the same parts.

Referring to Fig. 1 in more detail, there is shown a biased blocking oscillator type of pulse generator comprising a vacuum tube tetrode V1 whose control grid G and anode A are connected to separate windings L1 and L2, respectively, of a three winding transformer T. The transformer T is so coupled to the tube V1 that there is a regenerative action which gives very sharp increase of current in the tube V1 when the current is building up and very sharp decay when the current is decreasing, thus providing output pulses of sharp slopes or edges. Transformer T has low distributed capacitance between its windings in order to provide this desired rapid increase and decay of current therethrough. The grid G is supplied through resistor R with a negative bias potential from source $-E_c$ of a magnitude sufficient to normally cut off the flow of current through the tube. The anode is supplied through winding L2 with a positive polarizing potential from source $+B$.

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The third winding L3 of the transformer T is coupled to a source of external pulses which supplies the tripping input pulses. The windings of transformer T are so poled or connected that the circuit will regenerate; that is, the change in grid potential caused by an initial change in anode current will be of such polarity that it will cause a further change of anode current in the same direction.

The winding L3 is so poled or connected that a tripping input pulse of suitable polarity and magnitude will produce a pulse on the grid G of positive polarity and of a magnitude sufficient to overcome the negative bias provided by $-E_c$, and thus cause current to flow in the tube V1.

An artificial transmission line TL of several sections of series inductance L and shunt capacitance C is connected at one end across the resistor R. The other end of line TL is short-circuited by a direct connection, as shown. Resistor R is made to have a value equal to the characteristic impedance of line TL in order to avoid undesired wave reflections on the line. Line TL is known as a line with lumped constants. If each section (made up of one inductive and one capacitive unit) is considered individually, the time delay t in such a section (that is, the time it takes a pulse to flow through the section) is $t = \sqrt{LC}$ where L is the inductance and C the capacitance in each section. If the line has N identical sections, then the total one way time delay of the line is $N\sqrt{LC}$. If the individual sections are not identical, then the total one way time delay for a wave to travel down the entire length of the line is equal to the sum of the individual time delays of all the sections.

Although an artificial line TL has been illustrated, it should be understood that for the purpose of the invention the line may be a coaxial type or constructed with a spiral inner conductor as disclosed in Lindenblad copending application Serial No. 459,497, filed September 24, 1942.

A description of the operation of the system of Fig. 1 follows: Blocking oscillator V1 is normally biased to cut-off by the bias battery $-E_c$. If a tripping input pulse is applied to winding L3 of such polarity as to cause the grid G to swing in a positive direction so as to overcome the negative bias thereon, the tube will draw current very rapidly due to the regenerative action of the circuit. The application of the positive pulse to the grid G will be simultaneously applied to the input or sending terminals of line TL and will travel down the line toward the short-circuited end and charge the line with voltage of positive

polarity and with a magnitude determined by the pulse applied to the line. This traveling pulse on the line TL will be reflected at the short-circuited end as a pulse of opposite polarity (negative in this case) and will have substantially the same amplitude as the initial or direct pulse, assuming negligible attenuation along the line. The reflected pulse of negative polarity will travel back over line TL toward the grid G and will discharge the line completely when it returns to the grid, thus extinguishing the charge on the line. Any residual voltage produced by the reflected pulse will be dissipated in terminating resistor R. When the line is completely discharged, the bias on the grid G will return to the negative value furnished by source $-E_c$, thus cutting off the flow of current in tube VI. The flow of current through tube VI thus occurs for a period of time equal to the time it takes a pulse to travel down the entire length of line TL and return to the sending end; to wit, the time delay of a round trip on line TL. If the line TL has a one way time delay of T seconds, then the time duration of the flow of current through tube VI, or the time duration of the output pulse available from tube VI is 2T seconds.

It will thus be seen that an output pulse of sharp edges or slopes is available on the anode of tube VI only when a tripping pulse is applied to the tripping circuit terminal. Thus, the system of Fig. 1 will respond to input pulses at random intervals, but will always yield pulses of constant width determined by the time delay of the line TL, and of constant amplitude due to the fact that the tube can ordinarily be driven to the point where the grid current will start.

Although the operation of Fig. 1 has been described with particular reference to applying tripping input pulses to winding L3 of transformer T, it should be understood that the same results can be achieved by applying the tripping impulses to the grid at point Y. Output pulses can then be derived either from the anode A, as shown, or from the winding L3.

Where grid current saturation is to be used to limit the amplitude of the output pulses, then tetrode vacuum tubes as shown, or pentodes, should be used, because triodes will not provide as good clipping action by the method described above as the multi-grid tubes. The present invention utilizes grid current saturation to provide a flat top output pulse.

There are numerous variations possible of the system of Fig. 1 for practicing the invention, all of which operate on the same general principles set forth above in connection with Fig. 1. Figs. 2 to 5, inclusive, show some of these variations.

In Fig. 2 an embodiment is shown wherein the tripping input pulse of positive polarity is applied directly to the grid G of the tube VI through a condenser C1, while the winding L3 of transformer T may be used to provide push-pull output pulses. In this case, transformer T should be an efficient pulse transformer in order that the output from L3 be a faithful reproduction of the current pulse in winding L2. An output pulse can be taken from the anode A of VI in the same manner as shown in Fig. 1. The operation of the system of Fig. 2 is similar to that stated for Fig. 1, except for the foregoing differences noted.

Fig. 3 differs from Fig. 1 only in the method of obtaining the necessary cut-off bias for the grid of tube VI. In Fig. 3 the values of R1 and R2 are so chosen that the positive potential of the cathode is sufficient to bias the tube below cut-

off. It will be evident that the application of a positive potential to the cathode is equivalent to applying a negative potential to the grid. In some instances, an improvement in operation may be affected by by-passing or shunting resistor R2 with a condenser. If this is done, the cathode circuit time-constant should be very large compared to the pulse duration.

Fig. 4 is a variation of Fig. 3 in which the transformer T' has only two windings instead of three, and the tripping input pulse is applied to winding L1 as shown.

Fig. 5 shows an embodiment employing a triode tube V2 in place of the multigrid tubes of Figs. 1 to 4.

Due to the difficulty experienced in building transmission lines of long time delay, it is believed that the invention has its greatest application in supplying pulses of duration less than ten microseconds or thereabouts. The transformers employed in Figs. 1 to 5 should have as low a distributed capacitance of the windings as possible if it is desired to obtain steep-sided pulses, because the capacitance of the windings tends to slow the action of the circuit. It has been found that the current drain and the number of component parts required for the blocking oscillator circuit of the invention is less than that required for the two-tube trigger circuits.

I claim:

1. A pulse generator comprising an electron discharge device having an anode, a cathode and a grid, a transformer having separate coils in circuit with said anode and grid to produce regenerative coupling therebetween, means for biasing said device below cut-off, and a transmission line of predetermined electrical length short-circuited at one end and connected at its other end to said grid, and an input circuit for supplying to said device over a path independent of said line a pulse of such polarity and magnitude as to overcome the bias applied to said device to thereby cause a voltage wave of positive polarity to travel down the length of said line from the grid connected end and be reflected as a wave with negative polarity from the short circuited end.

2. A pulse generator comprising an electron discharge device having an anode, a cathode and a grid, a transformer having separate coils in circuit with said anode and grid to produce regenerative coupling therebetween, means for biasing said device below cut-off, and a transmission line of predetermined electrical length short-circuited at one end and connected at its other end to said grid, a resistor of a value equal to the characteristic impedance of said line terminating said line at said other end, and an input circuit for supplying to said device over a path independent of said line a pulse of such polarity and magnitude as to overcome the bias applied to said tube, to thereby cause a voltage wave of positive polarity to travel down the length of said line and be reflected as a wave with negative polarity from the short-circuited end.

3. A pulse generator comprising an electron discharge device having an anode, a cathode and a grid, a transformer having separate coils in circuit with said anode and grid to produce regenerative coupling therebetween, means for biasing said device below cut-off, and a transmission line of predetermined electrical length short-circuited at one end and connected at its other end between said grid and cathode, a re-

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sistor of a value equal to the characteristic impedance of said line terminating said line at said other end, and means for applying to said grid over a path independent of said line tripping pulses of a positive polarity of a magnitude sufficient to overcome the cut-off bias on said tube, to thereby cause a voltage wave of positive polarity to travel down the length of said line and be reflected as a wave with negative polarity from the short-circuited end.

4. A pulse generator comprising an electron discharge device having an anode, a cathode and a grid, a transformer having windings of low distributed capacitance separately coupled to said anode and grid and so poled as to produce regeneration, means biasing said grid negative relative to said cathode to a value below anode current cut-off, and a transmission line having a predetermined time delay for energy passing thereover coupled at one end to said grid, a terminating resistor for said one of said line having a value equal to the characteristic impedance of said line, a connection of low impedance to direct current shunted across the other end of said line, and an input circuit for supplying to the grid of said device over a path independent of said line a pulse of such polarity and magnitude as to overcome the bias applied to said device, to thereby cause a voltage wave of positive polarity to travel down the length of said line and be reflected as a wave with negative polarity, and an output circuit coupled to said anode for deriving, in response to each input pulse, a pulse of constant width whose time duration is a function of the delay time of said line.

5. A pulse generator comprising an electron discharge device having an anode, a cathode and a grid, a transformer having a pair of windings of low distributed capacitance separately coupled to said anode and grid and so poled as to produce regeneration, means biasing said grid negative relative to said cathode to a value below anode current cut-off, and a transmission line having a predetermined time delay for energy passing thereover coupled at one end to said grid, a terminating resistor for said one end of said line having a value equal to the characteristic impedance of said line, a connection of low impedance to direct current shunted across the other end of said line, a third winding of low distributed capacitance for said transformer, an input circuit for supplying pulses to said third winding of such polarity as to apply a positive pulse to said grid over a path independent of said line of such magnitude as to overcome the cut-off bias applied to said device, to thereby cause a positive voltage wave to travel down the length of said line and be reflected as a negative voltage wave, and an output circuit coupled to an electrode of said device for deriving, in response to said input pulses, pulses of constant width whose time duration is a function of the delay time of said line.

6. A pulse generator comprising an electron discharge device having an anode, a cathode and a grid, a transformer having a pair of windings of low distributed capacitance separately coupled to said anode and grid and so poled as to produce regeneration, means biasing said grid negative relative to said cathode to a value below anode current cut-off, and a transmission line having a predetermined time delay for energy passing thereover coupled at one end to said grid, a terminating resistor for said one end of said line having a value equal to the characteristic impedance of said line, a connection of low imped-

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ance to direct current shunted across the other end of said line, and a third winding of low distributed capacitance for said transformer, an input circuit for supplying to the grid of said device over a path independent of said line repeated pulses of positive polarity of magnitude sufficient to overcome the cut off bias on said grid, and an output circuit coupled to both terminals of said third winding for deriving push-pull output pulses of constant width whose duration is a function of the delay time of said line.

7. A pulse generator comprising a multi-grid vacuum tube including an anode, a cathode and a grid, a transformer having a pair of windings of low distributed capacitance separately coupled to said anode and grid and so poled as to produce regeneration, means for biasing said tube below anode current cut-off, and a transmission line of predetermined electrical length short-circuited at one end and connected at its other end to said grid, a resistor of a value equal to the characteristic impedance of said line terminating said line at said other end, and an input circuit for supplying to said device over a path independent of said line a pulse of such polarity and magnitude as to overcome the bias applied to said tube, to thereby cause a voltage wave to travel down the length of said line and be reflected as a wave with a polarity opposite to that of the initial wave, and an output circuit coupled to an electrode of said device for deriving in response to each input pulse, an output pulse of constant width whose time duration is equal to twice the delay time of said line.

8. A pulse generator in accordance with claim 5, characterized in this that said device, in a multi-grid vacuum tube, and said means for supplying a negative bias to said grid is a source of unidirectional potential whose negative terminal is connected to a point on said line terminating resistor.

9. A pulse generator in accordance with claim 5, characterized in this that said device is a multi-grid vacuum tube, and said means for biasing said grid negative relative to said cathode includes a connection from said cathode to the positive terminal of a source of unidirectional potential.

10. A blocking oscillator including a vacuum tube having an anode and a pair of grids, a transformer having separate coils in circuit with said anode and one of said grids to produce regenerative coupling therebetween, a transmission line of predetermined electrical length short-circuited at one end and connected at its other end to said one grid, an input circuit coupled to one of said coils for supplying tripping input pulses to said oscillator to cause said oscillator to pass current, and means including power supply connections coupled to the electrodes of said oscillator for causing grid current saturation when said oscillator conducts, whereby the amplitude of the output pulses is limited.

11. A blocking oscillator including a vacuum tube having an anode and a grid, a transformer having separate coils in circuit with said anode and grid to produce regenerative coupling therebetween, a transmission line of predetermined electrical length connected at one end to said grid, a connection of low impedance to direct current shunted across the other end of said line, and an input circuit coupled to one of said coils for supplying tripping input pulses to said oscillator, whereby the start of conduction in said tube causes a voltage wave of positive polarity to travel

down the length of said line and be reflected as a wave of negative polarity.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date	
2,154,484	Bell	Apr. 18, 1939	10

Number	Name	Date
2,212,173	Wheeler et al.	Aug. 20, 1940
2,212,202	Faudell	Aug. 20, 1940
2,212,420	Harnett	Aug. 20, 1940
2,227,076	Geiger	Dec. 31, 1940
2,266,154	Blumlein	Dec. 16, 1941
2,292,835	Kepp	Aug. 11, 1942
2,405,552	Blumlein et al.	Aug. 13, 1946
2,417,834	Lord	Mar. 25, 1947