Oct. 30, 1951 M. FISCHMAN 2,573,558

PULSE GENERATOR

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Fig. 1

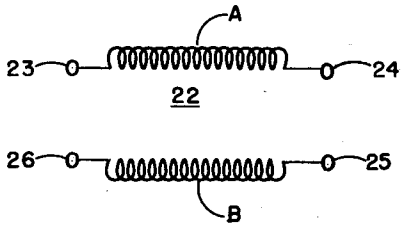


Fig. 2

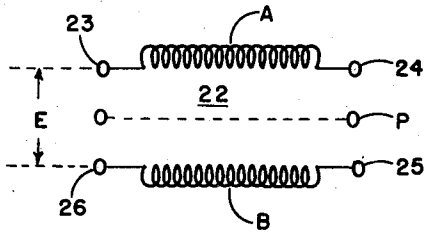
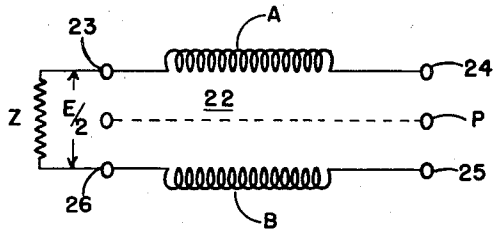


Fig. 3



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Fig. 4

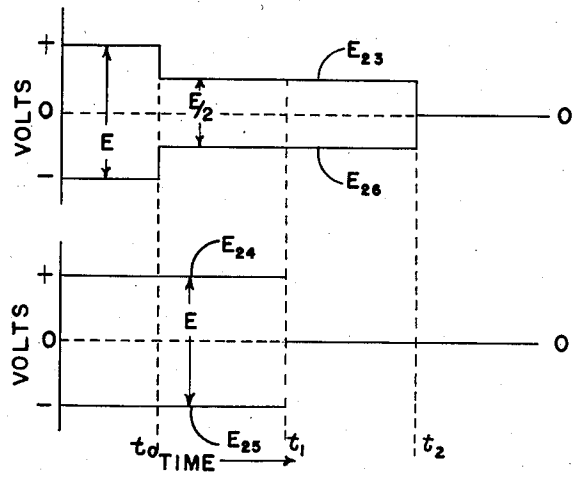
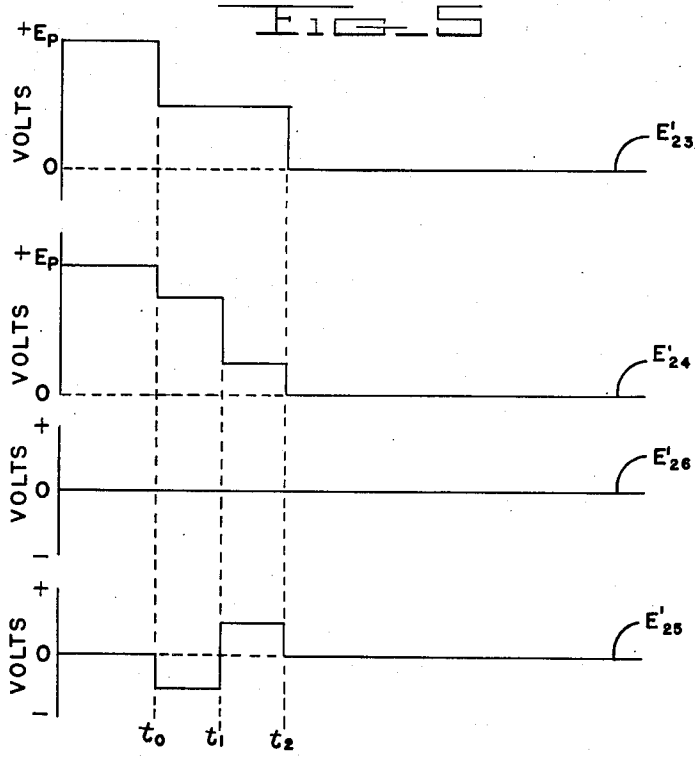


Fig. 5



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FIG. 6

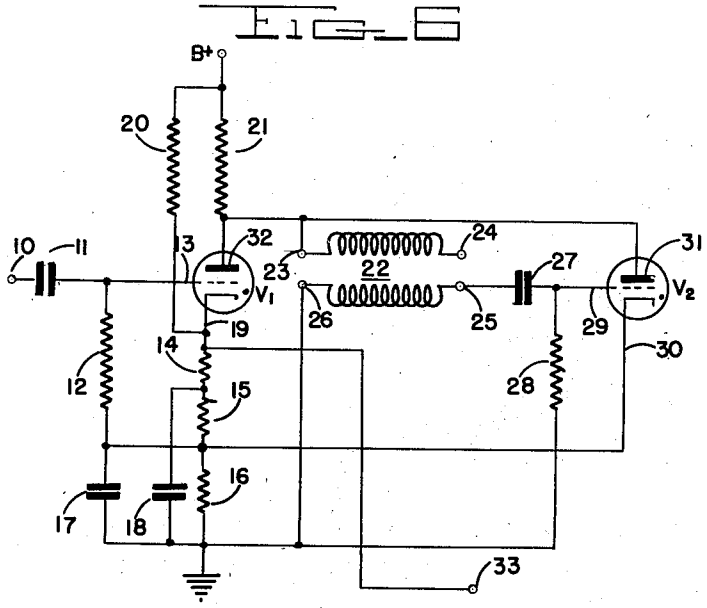
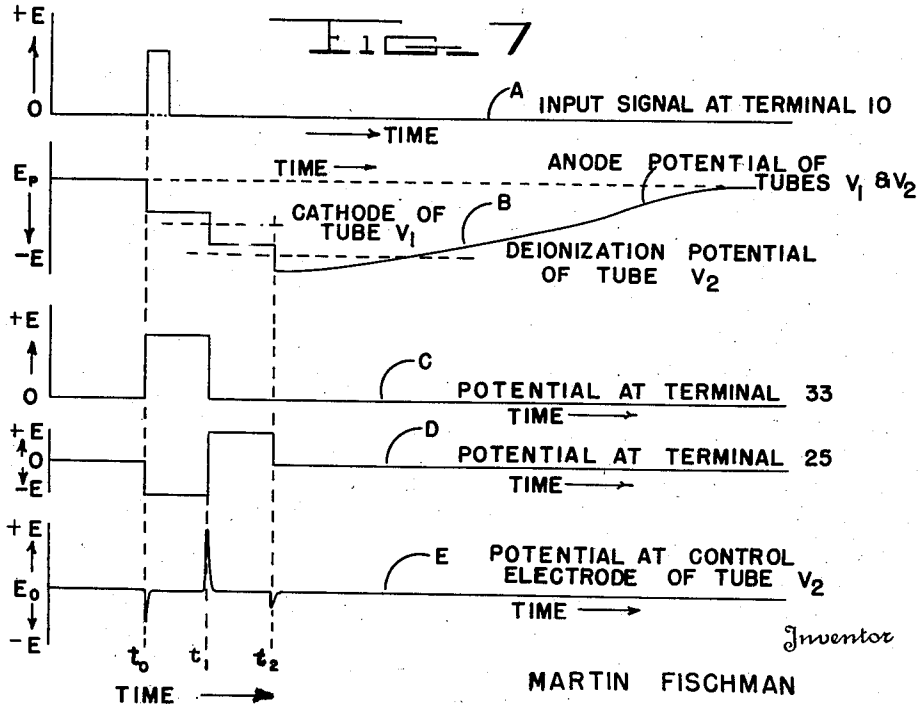


FIG. 7



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Patented Oct. 30, 1951 2,573,558

UNITED STATES PATENT OFFICE

2,573,558

PULSE GENERATOR

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Application October 10, 1945, Serial No. 621,573

7 Claims. (Cl. 250—27)

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This invention relates to a pulse generator wherein pulses are formed through the employment of an energy storage device.

More particularly, this invention relates, in general, to a pulse generator of the type wherein the desired pulses are obtained through the periodic charging and discharging of an energy-storage device such as a transmission-line section.

Pulse generators are known in the art in which an energy storage device is charged or discharged through a switching means. In such devices the shape of the pulse, particularly the leading and trailing edges, is determined by the characteristics of the energy storage device. Inasmuch as it is difficult to construct a distortionless storage device, pulses whose shape depends on the characteristics of the energy storage device often have long duration leading and trailing edges instead of the sharp discontinuities generally desired.

Accordingly this invention relates to a pulse generator wherein the slope of the trailing edge of a generated pulse is not dependent on the parameters of the transmission-line section which is used, but is determined by auxiliary means which are effective to shorten the duration of the trailing edge.

In the drawings, Figs. 1 to 3, inclusive, represent schematically a balanced transmission-line section or portions thereof and equivalent circuits therefore; Figs. 4 and 5 comprise a series of curves used in explaining the operation of the balanced transmission-line section used in the instant invention; Fig. 6 is a schematic circuit diagram of a pulse generator in accordance with the invention; and Fig. 7 comprises a series of curves used in the explanation of the operation of the Fig. 6 arrangement.

For a better understanding of the operation of a portion of the instant invention, reference is made to Figs. 1 to 5 inclusive, of the attached drawings which illustrate some of the characteristics of a balanced transmission-line section **22**.

Referring now more particularly to Fig. 1, there is illustrated the schematic circuit diagram of a balanced artificial transmission-line section **22** which is represented as a four terminal network comprising a pair of parallel-wound inductors A, B, with terminals **23**, **24**, **25**, and **26** as shown. It will be assumed that the network is initially charged to a potential designated E, as shown in Fig. 2, and that an equipotential plane or surface designated P, is disposed intermediate the two windings. This surface represents all

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points midway in potential between corresponding portions of the two inductors. It is now of interest to consider the variation, with respect to time, of the potentials of the various terminals when a resistor Z, as shown in Fig. 3, having an impedance equal to the characteristic impedance of the transmission-line section, is connected across terminals **23** and **26**. Inasmuch as the load Z is equal in magnitude to the impedance of the line, the potential across the terminals **23** and **26** will drop to one half its original value at the instant of the connection of the load Z. This is represented by the two steps occurring at time t_0 in the curves of Fig. 4, wherein the curve E_{23} represents the potential at terminal **23** with respect to the equi-potential plane, and curve E_{26} represents the potential at terminal **26** with respect to the equipotential plane P. These steps of voltage occurring at time t_0 are propagated down the line toward terminals **24** and **25** where they encounter a discontinuity at the open-circuited end at time t_1 and are reflected. This reflection will be of the same polarity as the steps developed at time t_0, and will arrive at the starting points comprising terminals **23** and **26** at a time t_2. It will be seen that the duration of interval t_0—t_2 is equal to twice the time required for the translation of a wave signal from one end of the line to the other. The arrival of these reflected wavefronts at the terminals **23** and **26** cause the potential there between to drop to zero at time t_2 as shown in curves E_{23} and E_{26} of Fig. 4.

Curves E_{24} and E_{25} of Fig. 4 represent the potentials which appear across terminals **24** and **25**. Prior to the arrival of the voltage step or wavefront from terminals **23** and **26** at time t_1, the potential across terminals **24** and **25** has the value E. However, at time t_1, the potential across terminals E_{24} and E_{25} drops to zero due to the simultaneous presnece of the incident and reflected waves, the sum of which has been shown to be zero.

The above curves represent the voltages at the various terminals with respect to the equipotential surface P. If, however, it is desired to express these voltages with respect to any one of the terminals, it is necessary to add a voltage equal to the voltage originally at the reference terminal to each of the terminals, but in the opposite sense, so that the terminal will correspond, in effect, to the equipotential plane P. Assume, for example, that the terminal **26** of the transmission-line section **22** of Fig. 3 is connected to ground. All voltages may then be conveniently taken with reference to this terminal. By mak-

ing the transformation described above, i. e., by adding a positive voltage—($-E_{26}$) to each of the curves of Fig. 4, the curves E'_{13}, E'_{24}, E'_{25}, and E'_{26} of Fig. 5 are obtained.

Referring now more particularly to Fig. 6, there is illustrated an input terminal 10 which is connected to the control electrode 13 of a thyratron V_1 through a condenser 11. The control electrode 13 is connected to ground by a resistor 12 and a parallel resistor-condenser combination comprising a resistor 16 and a condenser 17. The junction of resistors 12 and 16 is connected by resistors 14 and 15 to the cathode 19 of thyratron V_1, which is in turn connected by a resistor 20 to a source of voltage indicated by +B. An output terminal 33 is also connected to the cathode 19. A condenser 18, the impedance of which is low in comparison to the total resistance of resistors 15 and 16 is connected between the high potential terminal of resistor 15 and ground. The sum of the impedances of V_1 when conducting, plus resistor 14, plus condenser 18 at the pulse frequencies involved is made equal to the characteristic impedance of line 22. The anode 32 of thyratron V_1 is connected by a resistor to a source of potential indicated +B, and is directly connected to a terminal 23 of a balanced transmission-line section 22. The anode 31 of a second thyratron V_2 is also connected to terminal 23 of the transmission-line section, and its cathode 30 is connected to the junction of the resistors 15 and 16. The control electrode 29 of thyratron V_2 is connected through a condenser 27 to a terminal 25 of the transmission-line section, and is also connected to ground through a resistor 28 which, with condenser 27, comprises a differentiating circuit.

Coming now to the operation of the Fig. 6 arrangement, it is initially assumed that the thyratrons V_1 and V_2 are in a non-conducting state and that the transmission-line section 22 has been fully charged. A positive input pulse, shown as curve A of Fig. 7 is then applied to the control electrode 13 of thyratron V_1 through the condenser 11 at time t_0. This pulse momentarily overcomes the bias created by the voltage divider comprising resistors 14, 15, 16, and 20, and causes the thyratron V_1 to conduct. The relatively low impedance path thus presented across the terminals 23–26 of the transmission-line section 22 allows it to discharge through the resistor 14 and the condenser 18, the reactance of the latter effectively presenting a short-circuit across the resistors 15 and 16 insofar as the pulse delivered by the transmission-line section is concerned. The decrease in anode potential at time t_0 caused by the discharge of the transmission-line section 22 is illustrated by curve B of Fig. 7. The flow of current through the resistor 14 causes a voltage drop therein which comprises the leading edge and the constant amplitude portion of the output pulse of curve C of Fig. 7 which is delivered to the output terminal 33 between the interval t_0—t_1.

At time t_1, which denotes the end of the delay period t_0—t_1 of the line 22, the voltage at terminal 25 makes a sharp positive excursion as illustrated by curve D of Fig. 7. It will be manifest that this waveshape corresponds to that illustrated by wave E'_{25} of Fig. 5. This signal of curve D is coupled to the control electrode 29 of thyratron V_2 by the differentiating circuit comprising condenser 27 and resistor 28. The resultant differentiation creates the positive pulse which is illustrated in curve E of Fig. 7 at time

t_1 and overcomes the bias on thyratron V_2, thus causing it to conduct. Because of the fact that the cathodes of thyratrons V_1 and V_2 are returned to different points on the voltage divider comprising the resistors 14, 15, 16, and 20, the cathode 30 of thyratron V_2 is at a much lower potential than the cathode 19 of thyratron V_1. The voltage drop across the anode-cathode circuit of V_2, therefore, is sufficiently low, while it is in a conducting state, that the potential of the anode 31 of thyratron V_2, and consequently the anode 32 of thyratron V_1, is caused to be at a potential below that of the cathode 19 of thyratron V_1. Thyratron V_1, therefore, ceases to conduct, and the flow of current from transmission line section 22 through the resistor 14 which comprises the signal delivered to the output terminal 33, ceases abruptly at the time t_1 as illustrated in curve C of Fig. 7. At time t_2, the negative impulse which has been moving down the transmission-line section 22 arrives at the terminal 23, and this impulse serves to reduce the anode potential of thyratron V_2 sufficiently for conduction to cease therein. This is illustrated at time t_2 in curve B of Fig. 7. Deionization then taken place, the transmission-line section 22 is charged from the source indicated +B, and the arrangement is then ready to accept a subsequent positive pulse at the input terminal 10.

Although I have shown and described certain specific embodiments of the invention, I am fully aware of the many modifications possible thereof. This invention is not to be restricted except insofar as is necessitated by prior art and the spirit of the appended claims.

What is claimed is:

1. A circuit for generating a pulse of predetermined duration comprising the combination of energy storage means having a first terminal, a second terminal, and a third terminal, means connected to said first and second terminals effective to charge said energy storage means, an impedance and first switching means connected between said first and said second terminals and effective to initiate discharge of said energy storage means through said impedance, and second switching means connected between said first and second terminals and having a control element connected to said third terminal, said second switching means being responsive to signals appearing on said third terminal to remove the potential of the energy storage device from said impedance a predetermined time after initiation of discharge of said energy storage means.

2. A circuit for generating a square pulse of predetermined duration comprising in combination an artificial transmission line, means for charging the line, an impedance and first switch tube connected across one end of the line, actuation of said switch tube being effective to initiate discharge of the line through the impedance, and a second switch tube connected across said one end of the line and having a control element connected to the other end of said line, said first and second switch tubes having a common plate current supply path, whereby a pulse having sharp leading and trailing edges is generated across said impedance.

3. A circuit for generating a square pulse comprising an artificial transmission line, means for charging the line, an impedance and first switching means connected across one end of the line, actuation of said switching means being effective to initiate discharge of the line through the impedance, and a second switching means con-

nected across said one end of the line and having a control element connected to said other end of the line, whereby a pulse having a width corresponding with the length of the line is generated across the impedance.

4. A circuit for generating a square pulse of predetermined duration comprising in combination an artificial transmission line, means for charging the line, an impedance and first switching means connected across one end of the line, actuation of said switching means being effective to initiate discharge of the line through the impedance, a differentiating circuit connected to the other end of the line and operative to generate a spike when the reduced voltage caused by connecting the impedance across one end of the charged line travels to the other end of the line, and a second switching means connected across said one end of the line and having a control means connected to said differentiating circuit.

5. A circuit for generating a pulse of predetermined duration comprising the combination of an open-ended transmission line, a source of charging potential connected to one end of said line, a first switching means and an impedance connected in series across said one end of said line, and second switching means connected across said one end of said line and having a control element connected to the other end of said line.

6. A circuit for generating a pulse of predetermined duration comprising the combination of an open-ended transmission line, a source of charging potential connected to one end of said line, a first switching means and an impedance connected in series across said one end of said line, said impedance having a value equivalent to the characteristic impedance of said transmission line, and second switching means connected across said one end of said line and having a control element connected to the other end of said line.

7. A circuit for generating a pulse of predetermined duration comprising the combination of an open-ended transmission line, a source of charging potential connected to one end of said line, a first switching means and an impedance connected in series across said one end of said line, differentiating means connected to the other end of said line, and second switching means connected across said one end of said line and having a control element connected to said differentiating means.

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