April 25, 1950 H. C. LINDAHL 2,505,556

ELECTRICAL PULSE GENERATOR

Filed Dec. 30, 1944

FIG. 1.

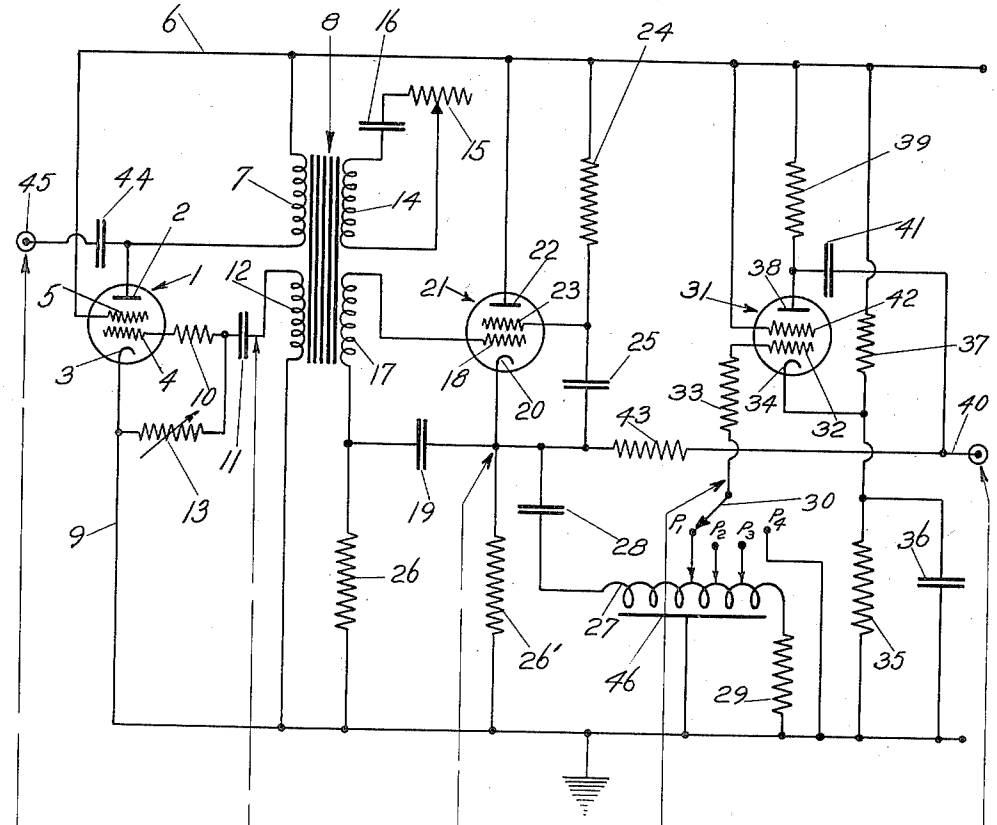
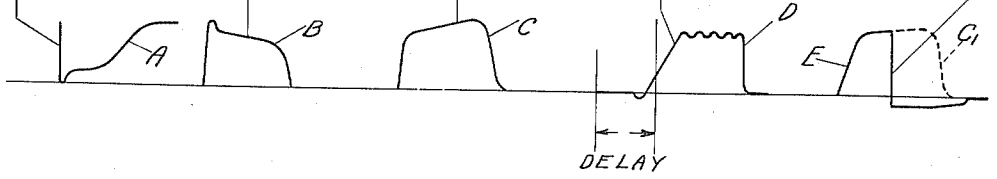


FIG. 2.



INVENTOR.
HILMER C. LINDAHL,
BY Elmer J. Gorn
ATTY.

Patented Apr. 25, 1950 2,505,556

UNITED STATES PATENT OFFICE

2,505,556

ELECTRICAL PULSE GENERATOR

Hilmer C. Lindahl, Waltham, Mass., assignor to Raytheon Manufacturing Company, Newton, Mass., a corporation of Delaware

Application December 30, 1944, Serial No. 570,671

2 Claims. (Cl. 250—27)

1

This invention relates to electrical systems and more particularly to pulse-forming circuits suitable, for example, for generating and shaping pulses of current having duration and repetition frequencies of the order required for the energization of a magnetron in radar equipment.

It is among the objects of the invention to provide a pulse-forming circuit the characteristics of which may be varied within wide limits at the will of the operator for the purpose of altering the repetition frequencies of the pulses generated by the system.

A further object of the invention is to provide a circuit of the type described in which the duration of the pulses generated can be controlled within wide limits.

A further object of the invention resides in the provision of a pulse-forming circuit in which adjustments for varying the repetition frequencies and for altering the pulse width or duration may be easily made by inexperienced operators.

A further object of the invention resides in the provision of a circuit of the type described which may be easily constructed of readily available materials and which will be sufficiently flexible to render it suitable for use under the varying conditions required by a magnetron test bench.

The above and other objects and features of the invention will be made fully apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawing in which:

Fig. 1 shows a circuit diagram illustrating an embodiment of the invention;

Fig. 2 shows a set of curves illustrating qualitatively rather than quantitatively the nature of the pulse generated at various points in the system.

Referring to the drawing, and especially Fig. 1, the system illustrated comprises a tube 1 which may be of the type designed for use in the output stage of radio receivers, such as a 6V6, and having a plate 2, an indirectly heated cathode 3, a grid 4 and a screen 5. A potential of about 300 volts is applied to the plate 2 from a supply line 6 through one of the windings 7 of a four-winding transformer 8. The cathode 3 is grounded through a lead 9. The grid 4 is connected through a resistor 10 and a condenser 11 to a second coil 12 of transformer 8, the opposite end of which is connected to ground. A variable resistor 13 is connected between the cathode lead 9 and the junction between resistor 10 and condenser 11.

When current flows through the plate winding 7 of transformer 8, a voltage is induced in the grid winding 12, driving the grid 4 positive through the condenser 11 and resistor 10. Resistor 10 prevents the tube 1 from being driven too hard and also serves to prolong the period

2

during which the tube 1 is conductive, thereby obtaining a pulse duration of approximately the desired length. After a predetermined time, in this instance about five microseconds, the charge on the condenser 11 becomes so high that the tube 1 is blocked, terminating the pulse of current. The charge on the condenser 11 leaks off through the variable resistor 13. The period of time required to leak off this charge depends on the value of the resistor 13, which value may be selected by the operator. Thus, the period of time before the start of the next pulse may be varied, and accordingly the repetition rate of the system may be controlled. The duration of the pulse of current through the tube 1 will depend not only upon the value of the resistance 10 and the capacity of condenser 11, but also upon the characteristics of the transformer 8. While these characteristics may be predetermined in the initial design and manufacture of the transformer to give the pulses the desired duration in a given circuit, I prefer to provide a means for controlling, within limits, the characteristics of the transformer. To this end the transformer 8 is provided with a third winding 14, the ends of which are connected through a variable resistor 15 and a condenser 16. Variation of the resistance 15 alters the pulse width. This variation also alters the repetition rate since it affects the feed back. Accordingly, in practice, the resistor 15 is first set to adjust the width of the pulse through the tube 1 to the desired duration and thereafter resistor 13 may be adjusted to give the desired repetition rate.

The fourth winding 17 of the transformer 8 applies the positive pulse through the tube 1, illustrated by the curve B of Fig. 2, between the grid 18 and the cathode 20 of a tube 21 through a coupling condenser 19. Tube 21, of the same type as tube 1, has its plate 22 connected to the supply line 6. The screen grid 23 of tube 21 is also connected to the supply line 6 through a voltage dropping resistor 24 and is also connected to the cathode 20 through a coupling condenser 25. Biasing resistors 26 and 26' are connected between the grid 17 and ground and between cathode 20 and ground, respectively. The condenser 19 is so large that its charge will not change appreciably during the duration of the pulse B applied between the grid 18 and the cathode 20. An amplified positive pulse of around 200 volts, illustrated by the curve C of Fig. 2, is obtained between the cathode 20 of the tube 21 and ground. Condenser 25 applies this pulse to the screen 23 so that tube 21 operates as a tetrode even though performing the functions of a cathode loaded amplifier.

The pulse C is also applied to a delay line 27 connected to the cathode 20 through a coupling condenser 28. The opposite end of the delay

line 27 is connected to ground through a resistor 29 which absorbs energy from the pulse and reduces the reflections produced by the pulse after passing through the delay line 27. The amount of the delay imposed upon the pulse by the delay line 27 can be selected by a switch 30 which may be closed at various points P_1, P_2 and P_3 along the delay line. The presence of phase distortion will give the delayed pulse a small negative component at the beginning thereof, as seen at the left-hand end of the curve D, and will also cause a small ripple in the top of the pulse, but these are of no consequence, provided they are not of extreme magnitude. The delayed pulse is applied to the grid 32 of a tube 31 through a resistor 33. The resistor 33 smooths out the irregularities in the pulse D, which are due to reflections. The tube 31 is of the same type as tubes 1 and 21 having a cathode 34 connected to ground through a biasing resistor 35 and a by-pass condenser 36. The cathode 34 is also connected to the supply line 6 through a voltage dropping resistor 37. The plate 38 of the tube 31 is connected to the supply line 6 through a voltage dropping resistor 39. The plate 38 is also connected to the output line 40 through a coupling condenser 41. A screen 42 of the tube 31 is directly connected to the supply line 6.

A negative pulse is obtained from the plate of the tube 31 delayed behind the pulse at the cathode of tube 21 by the amount of delay caused by the delay line 27. The undelayed pulse C at the cathode 20 of the tube 21 is applied to the output line 40 through the resistor 43. The delayed negative pulse on the plate 38 of the tube 31 combining with the positive pulse at the cathode 20 of the tube 21 cuts off or counteracts the right-hand end of the wave C to make this pulse shorter, as shown in the curve E of Fig. 2. The initial portion of this curve, together with the dotted line curve C', corresponds to the undelayed pulse C. The solid line curve E is the resultant of the curves C and D combined. When the switch 30 is in the last position P_4 to the right, the control grid 32 of the tube 21 is grounded, making this tube inoperative. In this case the full pulse C would be available at the output. As the switch is moved farther to the left to the point P_3, the clipping action of the pulse D is imposed upon the pulse C toward the end thereof and a long pulse is obtained. As the delay period is shortened by moving the switch to the points P_2 and P_1, the delay becomes less and less and the resultant length of the pulse E available at the output becomes shorter and shorter.

The output of the pulse-forming circuit shown may be utilized for various purposes where a pulse which is closely controllable with respect to both duration and repetition frequencies is desired. For example, the pulse may be applied by way of a concentric cable to the grid of a pulse amplifier and the amplified pulse used to energize a magnetron in radar equipment and is particularly suitable for the purpose of testing such magnetrons. When used for the latter purpose, it is advantageous to also derive a small voltage pulse simultaneously with the output voltage at 40 to operate the slave sweep circuit of a synchroscope. To this end a small negative voltage pulse indicated by curve A of Fig. 2 may be taken from the plate tube of the tube 7 by way of a coupling condenser 44 and a concentric cable 45.

From the foregoing it will be seen that the invention provides a pulse system in which both the repetition frequency and the duration of the pulse may be varied through wide limits by adjusting the value of resistance 13 and by adjusting the delay line 27 respectively. The value of the resistor 13 is preferably variable continuously or by small graduations from five megohms down to a low value. The delay line 27 should be comparatively flat to obtain even retardation along the length thereof. For this purpose I have successfully used a coil about 13½ inches long on a one inch fibre rod with $5\frac{3}{16}$'' x .0025 nickel strips running longitudinally thereof and grounded as indicated at 46. This is covered with one layer of three mil polystyrene over which is wound evenly No. 34 enamel wire to fill the rod.

While the invention has been described in conjunction with one embodiment thereof, other embodiments within the scope of the appended claims will be apparent to those skilled in the art from a consideration of the form shown and the teachings hereof. Accordingly, a broad interpretation of the appended claims commensurate with the state of the art is desired.

What is claimed is:

1. An electrical circuit comprising: a first means for generating recurrent voltage pulses; a second, adjustable means, incorporated in said first means, for controlling the width and recurrence frequency of said pulses continuously between preselected limits; a third means, receptive of said pulses, for deriving from each a delayed pulse; a fourth, adjustable means, incorporated in said third means, for controlling the amount of delay introduced; a fifth means, receptive of said delayed pulses, for amplifying and reversing the polarity of said delayed pulses; and a sixth means, receptive of said first-named and delayed pulses, for combining the same in vectorial opposition to obtain resultant pulses of selectively lesser width than said first-named pulses.

2. An electrical circuit comprising: a first means for generating recurrent voltage pulses; a delay line, receptive of said pulses, for deriving from each a delayed pulse; said delay line being tapped at spaced intervals along the length thereof to control the amount of delay introduced; an electron-discharge device, connected in circuit as a voltage amplifier, receptive of said delayed pulses, for amplifying and reversing the polarity of said delayed pulses; and a second electron-discharge device, connected in circuit as a cathode follower, and including a cathode resistor the value of which is equal to the input impedance of said delay line; said cathode resistor being receptive of said first-named and delayed pulses for combining the same in vectorial opposition to obtain resultant pulses of lesser width than said first-named pulses.

HILMER C. LINDAHL.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,059,683	Fransworth	Nov. 3, 1936
2,140,004	Falloon	Dec. 13, 1938
2,252,599	Lewis	Aug. 12, 1941
2,265,996	Blumlien	Dec. 16, 1941
2,266,154	Blumlien	Dec. 16, 1941
2,292,835	Hepp	Aug. 11, 1942
2,358,297	Bedford	Sept. 19, 1944