

Jan. 27, 1948.

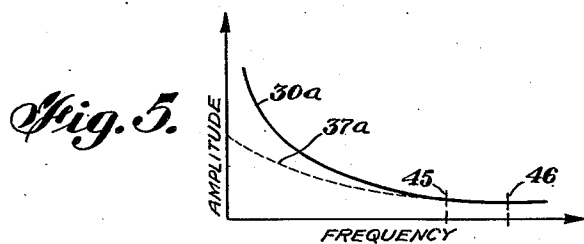
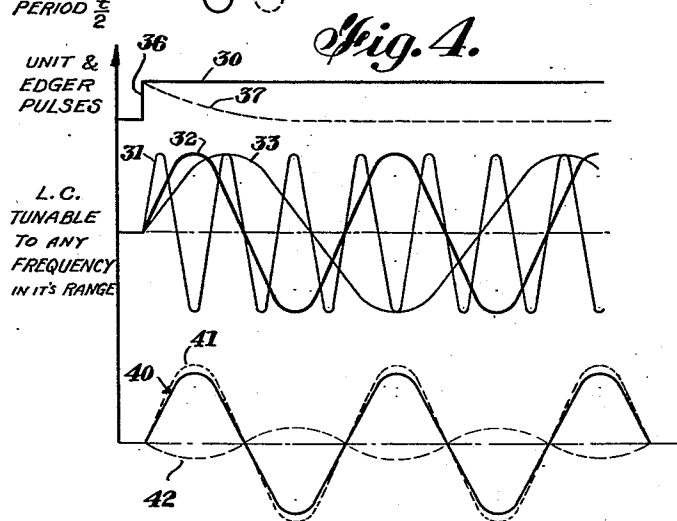
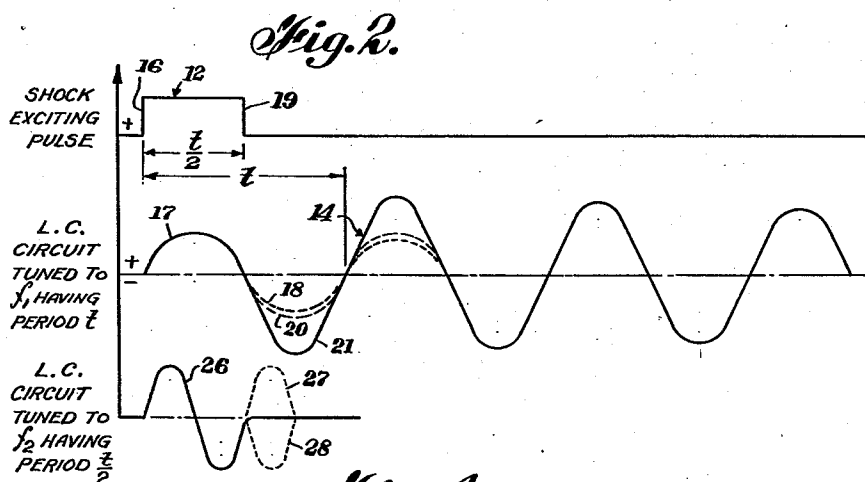
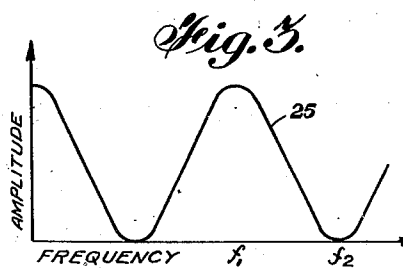
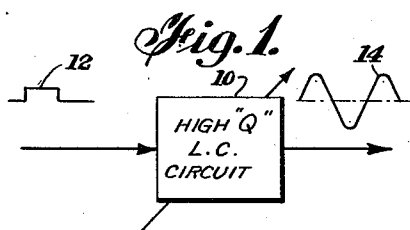
D. D. GRIEG

2,434,920

PULSE GENERATOR SYSTEM

Filed Nov. 23, 1943

2 Sheets-Sheet 1



INVENTOR.
DONALD D. GRIEG

BY *Ruby P. Lentz*
ATTORNEY

Jan. 27, 1948.

D. D. GRIEG

2,434,920

PULSE GENERATOR SYSTEM

Filed Nov. 23, 1943

2 Sheets-Sheet 2

Fig. 6.

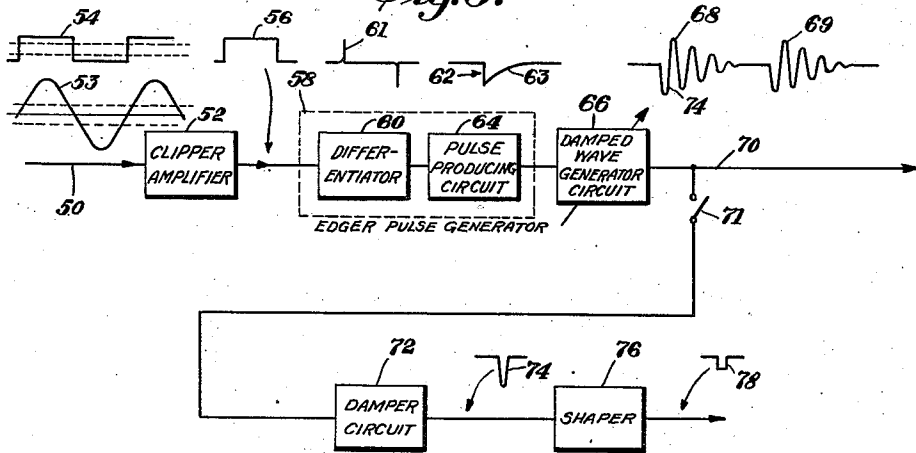


Fig. 7.

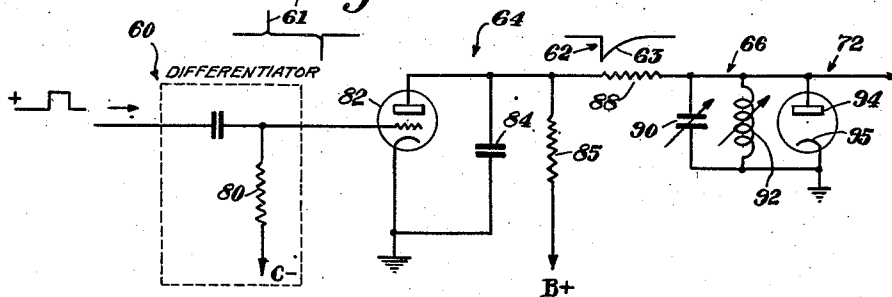


Fig. 8.

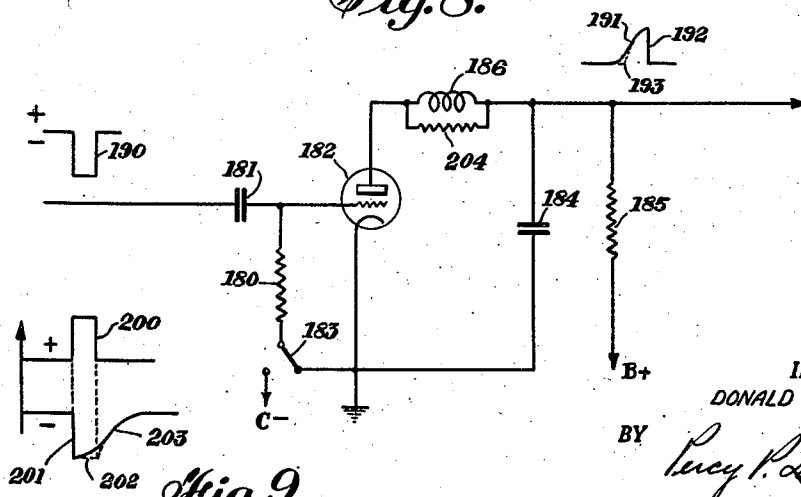
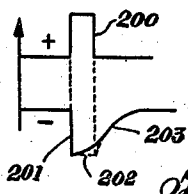


Fig. 9.



INVENTOR.
DONALD D. GRIEG

BY *Percy P. Lutz*
ATTORNEY

UNITED STATES PATENT OFFICE

2,434,920

PULSE GENERATOR SYSTEM

Donald D. Grieg, Forest Hills, N. Y., assignor to
Federal Telephone and Radio Corporation,
New York, N. Y., a corporation of Delaware

Application November 23, 1943, Serial No. 511,406

15 Claims. (Cl. 250—27)

1

This invention relates to wave and pulse generating systems particularly useful in radio and other electrical circuits.

It is one of the objects of my invention to provide a system for producing, from any given pulse shape, a wave of substantially a given amplitude characteristic for any desired frequency within a given wide band of frequencies and/or a pulse of any desired width within wide limits.

It is another object of my invention to provide a system for producing, from energy of a periodic wave or a train of recurring pulses, damped waves of substantially a given amplitude characteristic for any desired frequency within a given wide band of frequencies and in which the frequency selected is independent of the frequency of the input wave, the input pulse width or the input pulse repetition rate; or for producing from any such input energy a train of pulses having any desired pulse width within given limits.

A further object of my invention is to provide a system for producing, from a pulse substantially rectangular in shape, an "edger pulse" in which one edge (either the leading or trailing edge) is substantially vertical and the other is curved gradually in its build-up or decay as the case may be.

One of the important features of my invention comprises the generation of the "edger pulse" which, according to my definition, is a pulse form having one edge, either leading or trailing, which is substantially vertical while the other opposite edge is curved gradually, preferably in an exponential manner, in its build-up or decay. This edger pulse may be generated according to my invention from a pulse or undulation of any shape or width.

The edger pulse is particularly useful to shock excite a resonant circuit in conjunction with a damper means for producing damped waves of substantially a given amplitude characteristic for any desired frequency within a given wide band of frequencies or for producing pulses of any desired width within wide limits, the selection of frequency or pulse width being accomplished by merely controlling the tuning of the resonant circuit. The frequency of the wave produced is independent of the frequency or pulse repetition rate of the input energy and most important is also independent of the pulse width of the undulations or pulse shapes of the original input energy. Further, the widths of the pulse output of the system are independent of the widths of the input undulations or pulses.

The above and other objects and features of

2

the invention will become more clear upon consideration of the following detailed description to be read in connection with the accompanying drawings, in which:

Fig. 1 is a block diagram of a high "Q" LC circuit and Figs. 2, 3, 4 and 5 are graphical illustrations, the five figures being useful for explaining the theory of the edger pulse and its utility in the generation of waves and pulses according to the principles of my invention;

Fig. 6 is a block diagram of a system for producing damped waves and pulses;

Fig. 7 is a schematic wiring diagram of parts of the system of Fig. 6;

Fig. 8 is a schematic wiring diagram of a modified form of edger pulse generator; and

Fig. 9 is a graphical illustration of input and output pulse shapes for one operation of the generator shown in Fig. 8.

Before describing the system in which I employ the edger pulse for producing waves and pulses of selectable frequency and width respectively, it is believed desirable to first discuss the theory leading up to the edger pulse, its generation and use in my invention. It is known that a voltage wave of a particular frequency may be generated by shock exciting, by means of a current pulse, a resonant circuit such as indicated in block diagram at 10, Fig. 1, tuned to the desired frequency. A rectangular current pulse such as indicated at 12 in Fig. 2 having a width

$$\frac{t}{2}$$

is usually employed for a desired frequency the period of which is equal to t . The oscillations produced in the circuit 10 in response to the pulse 12 are illustrated by the curve 14. The leading edge 16 of the pulse 12 shock excites the circuit into oscillation producing a positive voltage undulation 17 during the first half of period t and tends normally to produce, in the second half of the period t , a negative undulation 18, and so forth as indicated by the broken lines. The trailing edge 19 of the pulse 12 operates to shock excite the circuit in a negative direction producing undulation 20 which combines with the undulation 18 to produce the ultimate undulation 21 from which the circuit continues to oscillate as indicated by the curve 14.

When the LC circuit is tuned to a period which is twice the width of the exciting pulse, an oscillation will be produced having maximum amplitude characteristics. This is indicated by the curve 25 of Fig. 3 in which f_1 indicates the tuned frequency the period of which is twice the width

3

of the shock exciting pulse. If the frequency is increased to f_2 such that the period thereof is exactly equal to the width of the shock exciting pulse, an oscillatory effect will be produced substantially as indicated at 26, Fig. 2. The leading edge 16 will shock excite the LC circuit into oscillation which passes through one positive and one negative undulation during the width of the pulse. The trailing edge 19 of the pulse upon shock exciting the circuit in a negative direction counters the force of the oscillation set up in the circuit by the leading edge thereby substantially cancelling each other. This opposite oscillation effect is indicated by the broken lines 27 and 28. If the circuit has a high "Q" the two opposed oscillatory energies will be substantially equal and completely cancel each other out. If the circuit is of a lower "Q," the later shock excitation will dominate and produce a small oscillation which, however, may be disregarded in this discussion.

This latter tuning effect is indicated at f_2 on the graph of Fig. 3 indicating that the output wave is of zero amplitude. For frequency adjustments between f_1 and f_2 , the variation in amplitude of the ultimate oscillation is indicated by the curve 25.

From the foregoing discussion, it is apparent that if the LC circuit 10 were shock excited by a unit pulse 30 (Fig. 4), that is to say by a pulse one edge of which is substantially vertical and which extends in width from such edge into infinity, the circuit would always respond as though it were shock excited by the one edge only. Thus, by using a theoretical unit pulse, or pulses of extremely long duration, waves of substantially a given amplitude characteristic could be produced by merely varying the tuning of the LC circuit. A plurality of waves of different frequencies that may be obtainable by shock excitation of a high "Q" LC circuit by a unit pulse are shown at 31, 32 and 33 of Fig. 4.

The production of the theoretical unit pulse, however, is not practical but, according to my invention, I produce an edger pulse which approaches the advantages obtainable from the theoretical unit pulse. As hereinbefore described, the edger pulse comprises a substantially vertical edge 36 which corresponds to the vertical edge of the unit pulse and an opposite edge which curves gradually as indicated at 37. The action of the edger pulse on the high "Q" LC circuit is indicated by the curve 40. The leading edge 36 shock excites the circuit as indicated by the broken line 41. The curved trailing edge 37 shock excites the circuit simultaneously in the opposite direction as indicated by the broken line 42. The curvature of the trailing edge, however, is such that the shock excitation produced thereby is negligible compared to the shock excitation produced by the vertical leading edge. The two excitations therefore produce a resultant oscillation in the circuit as indicated by the curve 40.

Fig. 5 shows two curves 30a and 37a of an amplitude-frequency graph indicating the change of amplitude of the oscillations producible by a theoretical unit pulse and an edger pulse, respectively. For very low frequencies the unit pulse would theoretically produce high amplitude oscillations which, as the frequency is increased, are reduced inversely proportional to the frequency in accordance with the increased power required for the higher frequencies as indicated by the curve 30a. The curve 37a has a lower curvature and tapers into the curve 30a as the frequency

4

increases. Thus, for a given band such as indicated by the limits 45 and 46, the amplitude of the resulting wave is substantially constant for any of the frequencies therebetween. It is this fact that makes the edger pulse of material importance in electrical circuits where a production of waves of substantially a given amplitude characteristic for any desired frequency in a given wide band are desired. As will be described hereinafter the edger pulse is also important for the production of pulses of any desired width within given limits.

In Fig. 6, I have illustrated by block diagram a system for generating an edger pulse and for using it in the generation of waves of desired frequency and for producing pulses of desired widths from input waves regardless of the shape and frequency thereof. The input 50 is applied to a clipper amplifier 52 whereby the wave form, whether sinusoidal as indicated at 53 or rectangular as indicated at 54, is gate clipped and amplified to produce a given rectangular shape as indicated by the rectangular pulse 56. The rectangular pulse 56 is applied to the edger pulse generator 58 whereby the edger pulse 62 is produced. In order to avoid corner effects in the curve portion 63 of the edger pulse, the generator preferably includes a differentiator 60 for producing an impulse 61 corresponding to the leading edge of the rectangular pulse 56. This positive impulse 61 is used to trigger a pulse producing circuit 64 whereby the edger pulse 62 is produced. The details of this circuit are shown in Fig. 7 and will be discussed in detail hereinafter.

The edger pulse 62 is applied to a damped wave generator circuit 66 whereby the vertical edge portion of the edger pulse shock excites the generator into oscillations substantially as indicated at 68. The next succeeding edger pulse will produce wave 69, it being understood that the energy of each wave is damped out before the next shock excitation of the circuit.

The wave trains 68 and 69, each of which corresponds to a single excitation by separate edger pulses, may be used for various purposes. The damped waves may, for example, be used for calibrating the tracing on a cathode ray oscilloscope. This may be accomplished by applying the wave directly to the deflecting electrodes of the oscilloscope or the wave may be clipped and differentiated to produce impulses which are applied to the deflecting electrodes.

By connecting the output circuit 70 through switch 71 to a damper circuit 72, it is possible to produce a pulse from each of the damped waves produced by the circuit 66. The damper circuit operates to pass the first undulation 74 of a wave and to damp out the remaining portion of the wave. The undulation 74 when applied to a pulse shaper 76 is reshaped to produce a preferred rectangular pulse 78 the width of which is equal to one half the period of the frequency of wave 68. Thus, by merely varying the tuning of the circuit 66 pulses of different widths may be produced.

The circuit of Fig. 7 shows schematically the details of the edger pulse generator 58, the damped wave generator circuit 66 and the damper circuit 72. The differentiator 60 is the usual condenser-resistor type, except that the resistor 80 thereof is also used for applying a negative bias on the grid of tube 82. This negative potential biases the tube 82 of the pulse producing circuit 64 to cut-off so that it is normally non-conductive. The tube circuit includes a condenser 84 connected between the plate and cathode electrodes

of the tube. The plate current is supplied through a resistor 85 so that the condenser 84 is charged exponentially as indicated by the curved portion 63 of the edger pulse 62. When the positive impulse 61 overcomes the cut-off bias on the tube 82, the tube is caused to conduct and discharge rapidly the charge on the condenser 84. This produces the substantially vertical edge portion of the edger pulse and the subsequent recharging of the condenser 84 produces the curved portion 63.

The edger pulse is applied through resistance 88 to the damped wave generator circuit 66 which includes a condenser 90 and an inductance 92 either or both of which may be adjustable. The vertical edge of the edger pulse shock excites the tuned circuit at whichever frequency it is tuned and since the curved edge portion 63 has negligible effect on the circuit, the circuit acts as though it were shock excited into oscillation by a unit pulse. Thus, for a given wide band of frequencies, the oscillations produced by the circuit are of substantially a given amplitude characteristic.

The damper circuit 72 includes a diode having the plate and cathode electrodes 94 and 95 connected across the inductance 92. The undulation 74 produced by the vertical edge portion of the edger pulse being of negative polarity prevents the diode tube from conducting but, as the oscillations pass through zero and become positive, the diode conducts thereby sharply reducing the "Q" of the tuned circuit to absorb the oscillatory energy set up by the vertical portion of the edger pulse. Thus, the damper circuit passes the energy of the first undulation 74 and damps out all further tendency of the circuit to oscillate. The undulation 74, of course, may be shaped as desired at 78.

In Fig. 8, I have shown a modified form of the edger pulse generator. The circuit generally is substantially the same as shown in Fig. 7 with the exception that the grid of the tube 182 may be biased with zero potential as indicated by the present position of the switch 183 or with a negative bias similarly as in the circuit of Fig. 7. The resistor 180 and the condenser 181, however, are here chosen of such time constant as not to operate as a differentiator circuit, thereby passing the incoming pulse substantially as received. The plate circuit includes an inductance 186 and resistance 204 which is used for smoothing out corner effects that are produced in the curved portion of the edger pulse when a rectangular pulse is applied to the grid of the tube 182.

Assuming that a negative pulse 190 is applied to the grid of the tube 182, while the tube is at zero bias, the negative pulse drives the tube to cut-off thereby permitting the plate current to charge the condenser 184 for the duration of the negative pulse thereby producing a curved build-up portion constituting a curved leading edge 191 for the edger pulse. The inductance 186 and resistance 204 operates to smooth out the corner effect indicated at 193 which would otherwise be produced by the abruptness of the leading edge of the input pulse. When the trailing edge of the input pulse occurs thereby returning the tube to zero bias, the condenser 184 discharges rapidly thereby producing a substantially vertical trailing edge 192 for the edger pulse.

It will be seen that by thus operating the circuit of Fig. 8, an edger pulse is produced in which the leading edge is curved and the trailing edge is substantially vertical. By changing the switch

183 to apply a negative potential to the grid of the tube 182 thereby normally driving the tube to cut-off, an edger pulse will be produced for positive input pulses wherein the leading edge is substantially vertical and the trailing edge is curved. This is illustrated graphically in Fig. 9 wherein positive pulse 200 is applied to the grid of the tube 182 with the tube biased to cut-off. The leading edge of the input pulse 200 causes the tube 182 to conduct and discharge the condenser 184 thereby producing the substantially vertical edge 201 for the edger pulse. The tube 182 is caused to flow for the duration of the pulse 200 which, in the absence of the inductance 186, would produce a constant voltage condition as indicated at 202 on the edger pulse. The trailing edge of the input pulse 200 returns the tube to cut-off thereby permitting the condenser 184 to recharge as indicated by the curved portion 203. The inductance 186 and resistance 204, however, smooths out the corner effect produced by the constant current flow indicated at 202 thereby producing a final curved trailing edge for the edger pulse which is of negligible effect when applied to the tuned circuit 66 of Fig. 7.

From the foregoing description, it will be readily apparent that by generating an edger pulse I am able to produce, by shock exciting a tunable circuit therewith, waves having a given amplitude characteristic for frequencies covering a wide band, and that by means of a damper circuit and shaper stage, to produce pulses of different widths. It will also be readily apparent that, where the energy of each wave is damped out prior to the occurrence of the next wave, the frequency of the waves is independent of the frequency of the input wave or the repetition of the input pulses or the width of the output pulses.

While I have described above the principles of my invention in connection with specific apparatus, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of my invention and the accompanying claims.

I claim:

1. A system for producing for each input pulse an output pulse of any desired width within given limits comprising means responsive to each input pulse for producing an edger pulse having leading and trailing edges in which one of said edges is substantially vertical and the other of said edges is curved gradually, a resonant circuit tuned to a frequency the period of which is twice the desired pulse width, means to apply said edger pulse to said resonant circuit, whereby the circuit is shock excited into oscillation by said vertical edge, the curved edge having negligible effect upon such oscillations regardless of the frequency to which said circuit is tuned and the width of said input pulse, means connected across said resonant circuit to permit one undulation to occur and damp out further tendency of the circuit to oscillate in response to an edger pulse, and means for shaping said one undulation into a pulse of substantially rectangular shape.

2. The system defined in claim 1 wherein the means connected across said resonant circuit includes a diode tube.

3. A system for producing for each input pulse a wave of substantially a given amplitude characteristic for any desired frequency within a given wide band of frequencies comprising means responsive to each input impulse for producing an edger pulse having leading and trailing edges

in which one of said edges is substantially vertical and the other of said edges is curved so gradually that when said edger pulse is applied to a resonant circuit said other of said edges has substantially negligible effect thereon, a damped resonant circuit tunable to any desired frequency in said band, and means to apply said edger pulse to said resonant circuit to shock-excite said circuit into oscillation at its tuned frequency in response to substantially only said vertical edge.

4. The system defined in claim 3 in combination with means to reshape the input pulse to insure a substantially rectangular input pulse shape.

5. The system defined in claim 3 wherein the input pulse is of rectangular shape and the means for producing the edger pulse therefrom includes means for differentiating said input pulse to produce a sharp impulse corresponding to one of the leading and trailing edges thereof.

6. The system defined in claim 3 wherein the input pulse is of a rectangular shape and the means for producing the edger pulse therefrom includes an inductance to smooth out any corner effects produced in said other edge due to the rectangular shape of said input pulse.

7. A system for producing for each input pulse a wave of substantially a given amplitude characteristic for any desired frequency within a given wide band of frequencies comprising means responsive to each input pulse for producing an edger pulse having a substantially vertical leading edge and a trailing edge exponentially curved so gradually that when said edger pulse is applied to a resonant circuit said trailing edge has substantially negligible effect thereon, a damped resonant circuit tunable to any desired frequency in said band, and means to apply said edger pulse to said resonant circuit to shock-excite said circuit into oscillation at its tuned frequency in response to substantially only said leading edge.

8. A system for producing for each input pulse a wave of substantially a given amplitude characteristic for any desired frequency within a given wide band of frequencies comprising means responsive to each input pulse for producing an edger pulse having the leading edge curved to represent a gradual build-up and the trailing edge substantially vertical, the leading edge being curved so gradually that when said edger pulse is applied to a resonant circuit said leading edge has substantially negligible effect thereon, a damped resonant circuit tunable to any desired frequency in said band, and means to apply said edger pulse to said resonant circuit to shock-excite said circuit into oscillation at its tuned frequency in response to substantially only said trailing edge.

9. A system for producing damped waves of substantially a given amplitude characteristic for any desired frequency within a given wide band of frequencies regardless of the frequency or undulation shape of the input wave energy, comprising means for producing a substantially rectangular pulse for each undulation of said input wave, means responsive to each rectangular pulse for producing an edger pulse in which one of the leading and trailing edges thereof is substantially vertical and the other is curved so gradually that when said edger pulse is applied to a resonant circuit said other of said edges has substantially negligible effect thereon, a damped resonant circuit tunable to any desired frequency in said band, and means to apply each edger

pulse to said resonant circuit to shock-excite said circuit into oscillation at its tuned frequency in response to substantially only said vertical edge.

10. A system for producing pulses of any desired width within given limits in response to input wave energy regardless of the frequency or undulation shape of the input wave energy comprising means for producing a substantially rectangular pulse for each undulation of said input wave, means responsive to each rectangular pulse for producing an edger pulse in which one of the leading and trailing edges thereof is substantially vertical and the other is curved so gradually that when said edger pulse is applied to a resonant circuit said other of said edges has substantially negligible effect thereon, a damped resonant circuit tunable to any desired frequency in said band, means to apply said edger pulse to said resonant circuit to shock-excite said circuit into oscillation at its tuned frequency in response to substantially only said vertical edge, and means connected across said resonant circuit to permit one undulation of each damped wave thus produced to pass and to damp out further tendency of the circuit to oscillate for such damped wave, and means for shaping said one undulation into a pulse of substantially rectangular shape.

11. A system for producing an edger pulse in response to an input pulse of any wave form comprising means to reshape the input pulse to insure a substantially rectangular input pulse shape, a vacuum tube, a condenser, means connecting said condenser between the plate and cathode electrodes of said tube, a resistor, means to supply the plate electrode with current through said resistor whereby said condenser is chargeable exponentially, and means to apply said rectangular input pulse to the grid electrode of said tube to control conduction of said tube for rapid discharging of said condenser in time relation with one of the edges of said input pulse to produce a substantially vertical edge for said edger pulse, the opposite edge of said edger pulse being curved according to the charging characteristics of said condenser and said resistor.

12. The system defined in claim 11 in combination with means for negatively biasing said tube to cut-off, and wherein the means for applying the input pulse includes means for differentiating the rectangular pulse thereby producing sharp impulses corresponding to the leading and trailing edges of said input pulse and means to apply one of said impulses to the grid of said tube to make the leading edge of said edger pulse substantially vertical and the trailing edge curved exponentially, the vertical edge thereof corresponding in time to said one impulse.

13. The system defined in claim 11 in combination with means for negatively biasing said tube to cut-off, and wherein the means for applying the input pulse is arranged to apply the input pulse with positive polarity to make the leading edge of said edger pulse substantially vertical and the trailing edge curved, and the means for supplying the plate electrode with current includes an inductance which operates to smooth out any corner effects produced in the curved edge due to the rectangular shape of said input pulse.

14. The system defined in claim 11 in combination with means to apply zero bias on said tube, and wherein the means for applying the input pulse is arranged to apply the pulse with negative polarity to make the leading edge of said edger pulse curved and the trailing edge sub-

stantially vertical, and the means for supplying the plate electrode with current includes an inductance which operates to smooth out any corner effects produced in the curved edge due to the rectangular shape of said input pulse.

15. A system for producing an edger pulse in response to an input pulse of substantially rectangular shape comprising a vacuum tube, a condenser, means connecting said condenser between the plate and cathode electrodes of said tube, a resistor, means to supply the plate electrode with current through said resistor whereby said condenser is chargeable exponentially, said means including an inductance, and means to apply said rectangular input pulse to the grid electrode of said tube thereby producing current flow through said tube for the duration thereof and thereby causing rapid discharging of said condenser in time relation with one of the edges of said input pulse to produce a substantially vertical edge for said edger pulse, the opposite edge of said pulse being curved according

to the charging characteristics of said condenser and said resistor, said inductance operating to smooth out any corner effects produced in the curved edge portion of the edger pulse because of the rectangular shape of the input pulse.

DONALD D. GRIEG.

REFERENCES CITED

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

UNITED STATES PATENTS

	Number	Name	Date
	2,153,202	Nichols -----	Apr. 4, 1939
15	2,280,707	Kell -----	Apr. 21, 1942
	2,181,309	Andrieu -----	Nov. 28, 1939
	2,063,025	Blumlein -----	Dec. 8, 1936
	2,084,157	McLennan -----	June 15, 1937
	2,114,938	Puckle -----	Apr. 19, 1938
20	1,908,249	Hund -----	May 9, 1933
	2,103,090	Plebanski -----	Dec. 21, 1937