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D. E. NORGAARD
ELECTRONIC SIGNAL GENERATOR

2,471,836

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Fig. 1.

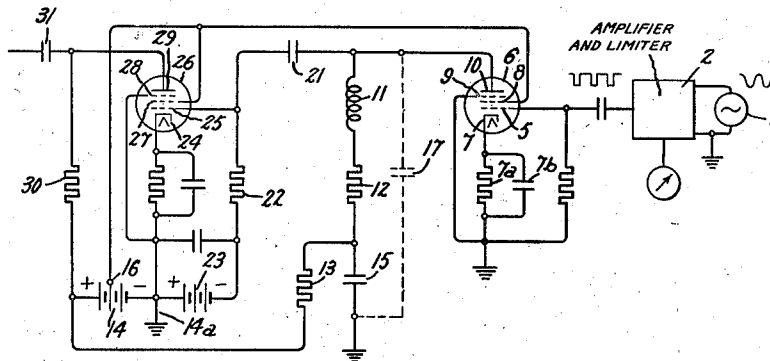


Fig. 2.

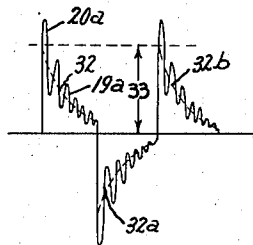


Fig. 3.

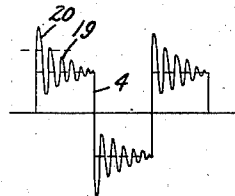
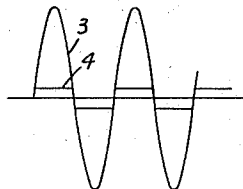


Fig. 4.



Inventor:
Donald E. Norgaard,
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

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ELECTRONIC SIGNAL GENERATOR

Donald E. Norgaard, Scotia, N. Y., assignor to
General Electric Company, a corporation of New
York

Original application June 8, 1942, Serial No.
446,231. Divided and this application June 2,
1944, Serial No. 538,496

12 Claims. (Cl. 250-27)

1

This application is a division of my copending application, Serial No. 446,231, filed June 8, 1942, entitled Cathode ray apparatus, and assigned to the same assignee as the instant application.

My present invention relates to pulse systems, and particularly to electric impulse generating circuits. The invention is especially applicable to radio echo finding equipment and radio communication equipment. As described in the above copending application, electric voltage pulses of the described character may be used in a variety of ways, such as to control cathode ray discharge devices and the like.

It is a general object of my invention to provide a new and improved electric circuit for the generation of electric impulses of short duration.

It is a further object of my invention to provide a new and improved transient voltage response circuit for generating electric voltage pulses having a duration of the order of less than a microsecond.

In accordance with my invention, a substantially rectangular voltage wave is impressed upon a circuit of such character that the leading edge of each rectangular half wave initiates a transient or damped high frequency oscillation which is thus superposed upon the square wave. The thus distorted square wave is then differentiated to exaggerate the difference in amplitude between the first and second positive voltage swings of the high frequency oscillations occurring during each half cycle of the square wave voltage. The resulting wave is then used to control a clipper tube which is so biased that it does not conduct unless its control voltage is raised above a threshold value less than the first positive high frequency voltage peak, but greater than the remainder of the distorted square wave. In this manner the clipper tube is triggered upon each positive half cycle of square wave voltage and for the duration of less than a half cycle of the superposed high frequency oscillation.

My invention itself will be more fully understood and its objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing, in which Fig. 1 is a schematic circuit diagram of a pulse generating circuit embodying my invention; and Figs. 2, 3 and 4 are graphical representations of certain of the voltage characteristics of the circuit shown at Fig. 1.

At Fig. 1, I have shown at 1 a source of oscillations having a frequency equal to the desired repetition rate of the pulses to be generated,

2

The character of the source 1 is not an essential feature of the present invention, but preferably the source 1 comprises a crystal or electron discharge oscillator having an output voltage of substantially sine wave shape. Likewise, the frequency of the source 1 is immaterial to the operation of my invention. By way of example, however, reference may be had to my aforementioned copending application, wherein is described a complete cathode ray apparatus utilizing my present invention with the sine wave source 1 having a frequency of approximately 82 kilocycles per second.

The sine wave output from the source 1 is connected to the input of an amplifier and limiter 2. The amplifier and limiter 2 may be of any suitable type designed to supply at its output circuit a square wave derived from the sine wave input from the source 1. At Fig. 4 I have shown a curve 3 representing the sine wave applied to the input of the amplifier and limiter 2. As a result of its amplitude limiting action, the output of the limiter 2 has the form of the approximately square wave 4 of Fig. 4.

The square wave voltage output from the limiter 2 is applied to the grid or input control electrode 5 of an electron discharge amplifying device 6. The amplifier 6 includes a cathode 7, a screen grid 8, a suppressor grid 9 and an anode 10. The cathode 7 is grounded through a resistor 1a and bypass condenser 7b. The amplifier anode 10 is connected through an inductance 11 and resistances 12 and 13 to a suitable source of positive anode potential, such as a battery 14. The battery 14 is grounded at 14a and the battery and resistor 13 are by-passed to ground by a condenser 15. The screen grid 8 of the amplifier 6 is supplied with a suitable positive potential from an intermediate point 16 on the battery 14. The suppressor grid 9 is connected directly to ground. In operation the square wave applied to the amplifier control grid 5 produces square wave pulses of current in the amplifier anode circuit including the inductance 11, resistance 12, and by-pass condenser 15. This anode circuit is shunted by a certain amount of inherent stray and distributed capacitance, represented on the drawing by a condenser 17 shown in dotted lines. It will be understood that each change in current in the inductance 11 initiates a transient voltage oscillation in the resonant anode circuit 11, 12, 15, 17. This damped voltage oscillation has a frequency determined by the constants of the resonant anode circuit itself, and this frequency is much higher than the frequency of the square

3

wave input supplied to the amplifier 6. At Fig. 3, I have shown the square voltage wave 4 representing the input voltage to the amplifier 6, and I have also shown, superposed upon the square wave 4, an oscillatory transient voltage 19. The combined oscillations 4 and 19 represent the voltage across the resonant anode circuit 11, 12, 15, 17. It will be noted that the first cycle 20 of each high frequency oscillatory transient is of considerably greater amplitude than the later cycles, since the oscillatory transient is rapidly damped throughout the period of each half cycle of the square wave oscillations.

The square wave 4, with its superposed oscillatory transient 19, is supplied to a differentiating circuit comprising a condenser 21 and a resistance 22 connected in series circuit relation with a suitable source of negative biasing potential, such as a battery 23, across the resonant anode circuit of the amplifier 6. The voltage across the resistance 22 and battery 23 in series is applied between the cathode 24 and control electrode or grid 25 of an electron discharge device or clipper tube 26. The battery 23 is grounded at 14a and serves to bias the control electrode 25 negatively, so that the discharge device 26 will not conduct except when positive potential above a certain predetermined threshold value is supplied through the coupling condenser 21. The discharge device 26 includes also a screen electrode 27 connected to the point 16 on the battery 14, a suppressor electrode 28 connected directly to ground at 14a and an anode 29 connected through a load resistor 30 to the positive terminal of the battery 14. The anode voltage of the discharge device 26 is supplied through a coupling condenser 31 to any suitable utilization circuit which may, for example, comprise the deflection electrodes of a cathode ray discharge device.

By reason of the operation of the differentiating circuit including the condenser 21, the square voltage wave 4 is not reproduced as a square wave across the resistor 22, but rather appears thereon in the form of the wave represented by the dotted line 32 of Fig. 2. That is, when the current is a minimum in the device 6, its anode 10 is at high positive potential and the condenser 21 assumes a certain charge. During a positive pulse on the grid 5 of the device 6, current increases in the anode 10 thereby causing the condenser 21 to discharge to a certain extent through the resistor 22, as represented by the portion 32a of the curve 32 of Fig. 2. During the negative portion of the square wave, the current drops in the device 6 and its anode potential rises. The condenser 21 then commences to charge and current flows in the resistor 22 in accordance with the portion 32b of the curve 32 of Fig. 2. The cycle repeats continuously in this manner. It will be seen that the portions 32a and 32b of the curve 32 are quite steep. It will be understood, of course, that the transient oscillations 19 of Fig. 3 are superposed also upon the curve 32, as represented at Fig. 3 by the curve 19a. However, because of the steepness of the charge and discharge portions of the curve 32 of Fig. 2, the difference in the peak amplitudes of the first and second positive voltage swings of each transient oscillation is greatly exaggerated in comparison to the amplitude difference apparent on the square wave base of Fig. 3.

The resultant voltage wave of Fig. 2 appears across the resistor 22 and is applied to the grid 25 of the discharge device 29. The discharge device 29 is biased negatively by the battery 23 to such an extent that a positive voltage greater in ampli-

4

tude than a threshold voltage 33 of Fig. 2 must appear upon the grid 25 before the discharge device 26 conducts. Accordingly, it is evident that no part of the voltage wave of Fig. 2 has any effect upon the discharge device 26 except the first positive high frequency oscillatory voltage swing 20a at the leading edge of each positive half cycle of the low frequency oscillations. It is only this first transient voltage swing which exceeds the threshold voltage 33 necessary to overcome the cutoff bias of the discharge device 26. Accordingly, in the anode circuit of the discharge device 26, pulses of current flow only once per cycle of the square wave oscillations and for only the period of a portion of the short transient positive voltage swing 20a of Fig. 2.

It will be understood that these current pulses may be of high intensity and are of very short duration. For example, when the source 1 has a frequency of 82 kilocycles per second, the duration of one positive half cycle of the square wave 18 of Fig. 3 is approximately 6 microseconds, so that the duration of a pulse discharge resulting from the transient positive voltage swing 20a of Fig. 2 will be of even much shorter duration.

While I have described only one preferred embodiment of my invention by way of illustration, many modifications will occur to those skilled in the art and I, therefore, wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent in the United States is:

1. In combination, a source of sine wave electromotive force, means to convert said sine wave electromotive force to unidirectional electromotive force varying cyclically and abruptly between different values, means to superpose upon consecutive half cycles of said unidirectional electromotive force an oscillatory transient of rapidly decreasing intensity during the half cycle to produce a combined wave in which a sharp intense pulse of maximum amplitude is produced at the beginning of each of alternate half cycles, a load circuit, and means to select said sharp intense pulses and to supply them to said load circuit.

2. In combination, a source of square wave voltage, means to convert said square wave voltage to a voltage of wave form having maximum intensity in one polarity at the beginning of each alternate half-cycle, means to superpose upon consecutive half cycles of said voltage an oscillatory transient of rapidly decreasing intensity during the respective half cycle to produce a combined wave, a load circuit, and means to supply to said load circuit a single pulse in response to the oscillatory transients superposed upon alternate half-cycles of said voltage in said combined wave.

3. In combination, an electron discharge device having an anode, a cathode, and a control electrode, a source of square waves connected between said control electrode and cathode, a source of operating potential, an inductance and a resistance connected between said anode and cathode whereby said square waves are reproduced between said anode and cathode, means providing capacity between said anode and cathode resonating with said inductance at a frequency much higher than the frequency of said square wave, whereby an oscillatory transient is superposed upon each half cycle of said square wave in said anode circuit to produce a combined wave, a resistance and a condenser con-

5

nected between said anode and cathode, a load circuit, and means to pass current to said load circuit in response only to variations in voltage on said last resistance due to said combined wave exceeding the variations produced thereon by said second square waves alone.

4. A pulse generating circuit comprising a source of electric oscillations of substantially rectangular wave form and of relatively low frequency, means for superposing upon consecutive half cycles of said rectangular oscillations transient oscillations of appreciably higher frequency and rapidly decreasing intensity to produce a combined wave, and means responsive only to said high frequency oscillations at the beginning of each of alternate half cycles said combined wave to initiate discrete voltage pulses of short duration.

5. A pulse generating circuit comprising a source of electric oscillations of substantially rectangular wave form and predetermined frequency, means for superposing upon each half cycle of said rectangular wave high frequency oscillations of rapidly diminishing intensity to produce a combined wave, and means responsive only to the maximum half cycle intensity of one polarity in said high frequency oscillations in said combined wave for establishing a discrete voltage pulse duration once per cycle of said rectangular wave.

6. A pulse generating circuit comprising a source of electric oscillations of substantially rectangular wave form and predetermined frequency, means for superposing upon half cycles of said rectangular wave damped oscillations of appreciably higher frequency to provide a combined wave having half cycles of oscillatory and diminishing intensity, means for differentiating said combined wave to exaggerate the decrease in intensity of half cycles of said combined wave, and means responsive only to the initial oscillatory intensity of said differentiated wave for establishing discrete voltage pulses of short duration.

7. A pulse generating circuit comprising a source of electric oscillations of substantially rectangular wave form and predetermined frequency, means for superposing upon each half cycle of said rectangular waves a damped high frequency transient oscillation of rapidly diminishing intensity, an electron discharge device including an anode, a cathode, and a control electrode, means for impressing the combined oscillations upon said control electrode, and means for rendering said discharge device substantially non-responsive to oscillations below a predetermined threshold intensity less than the maximum intensity of said combined oscillations.

8. A pulse generating circuit comprising an electron discharge device having an anode, a cathode, and a control electrode, means for supplying to said control electrode electric oscillations of substantially rectangular wave form and predetermined frequency, an anode circuit for said discharge device including a resonant circuit tuned to a frequency appreciably higher than said predetermined frequency, said resonant circuit superposing upon each rectangular half wave in the output of said discharge device a damped high frequency oscillation, and means responsive only to the initial maximum intensity of one polarity in alternate half cycles of the combined oscillations for establishing discrete electric pulses having a duration of the order of a half cycle of said high frequency oscillations.

9. A pulse generating circuit comprising an

6

electron discharge device having an anode, a cathode and a control electrode, means for supplying to said control electrode electric oscillations of substantially rectangular wave form and predetermined frequency, an anode circuit for said discharge device including energy storing means for superposing upon each rectangular half wave in said anode circuit transient electric oscillations of high frequency and rapidly diminishing amplitude, means for differentiating the combined oscillations in said anode circuit to exaggerate the amplitude difference between first and second cycles of said high frequency oscillations, a second electron discharge device, means for supplying said differentiated oscillations to said second electron discharge device, and means for rendering said second electron discharge device substantially non-responsive to oscillations having less than a predetermined threshold amplitude, said differentiated oscillations exceeding said threshold amplitude only at the said first cycle of each of said transient oscillations occurring in alternate half-cycles of said first-mentioned oscillations.

10. A pulse generating circuit comprising an electron discharge device having an anode, a cathode and a control electrode, means for supplying to said control electrode electric oscillations of substantially rectangular wave form and predetermined frequency, an anode circuit for said discharge device including energy storing means, said energy storing means superposing upon each half cycle of said rectangular oscillations damped high frequency oscillations, a second electron discharge device having an anode, a cathode and a control electrode, means for normally maintaining said second discharge device non-conductive, and means for supplying to the control electrode of said second discharge device the combined oscillations in said anode circuit, thereby to trigger said second discharge device once per cycle of said rectangular oscillations and for the duration of one half cycle of said high frequency oscillations.

11. A pulse generating system comprising, in combination, means to produce a periodic pulse wave having maximum intensity in one polarity with respect to the alternating current axis of said wave near the beginning of each pulse of said polarity, means to superpose upon each said pulse a relatively high frequency, damped oscillatory transient also having maximum intensity of said polarity near said beginning, thereby to form a combined wave having a short intense peak near the beginning of each said pulse, a load circuit, and means to supply to said load circuit a single short pulse in response to each of said peaks of said combined wave.

12. A pulse generating system comprising, in combination, means to produce a periodic pulse wave having maximum intensity in one polarity with respect to the alternating current axis of said wave near the beginning of each pulse of said polarity, means to superpose upon each said pulse a relatively high frequency, damped oscillatory transient also having maximum intensity of said polarity near said beginning, thereby to form a combined wave having a short intense peak near the beginning of each said pulse, means to select only peak portions of said combined wave exceeding said maximum intensity, and means to supply said peak portions to a utilization circuit.

DONALD E. NORGAARD.

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7

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