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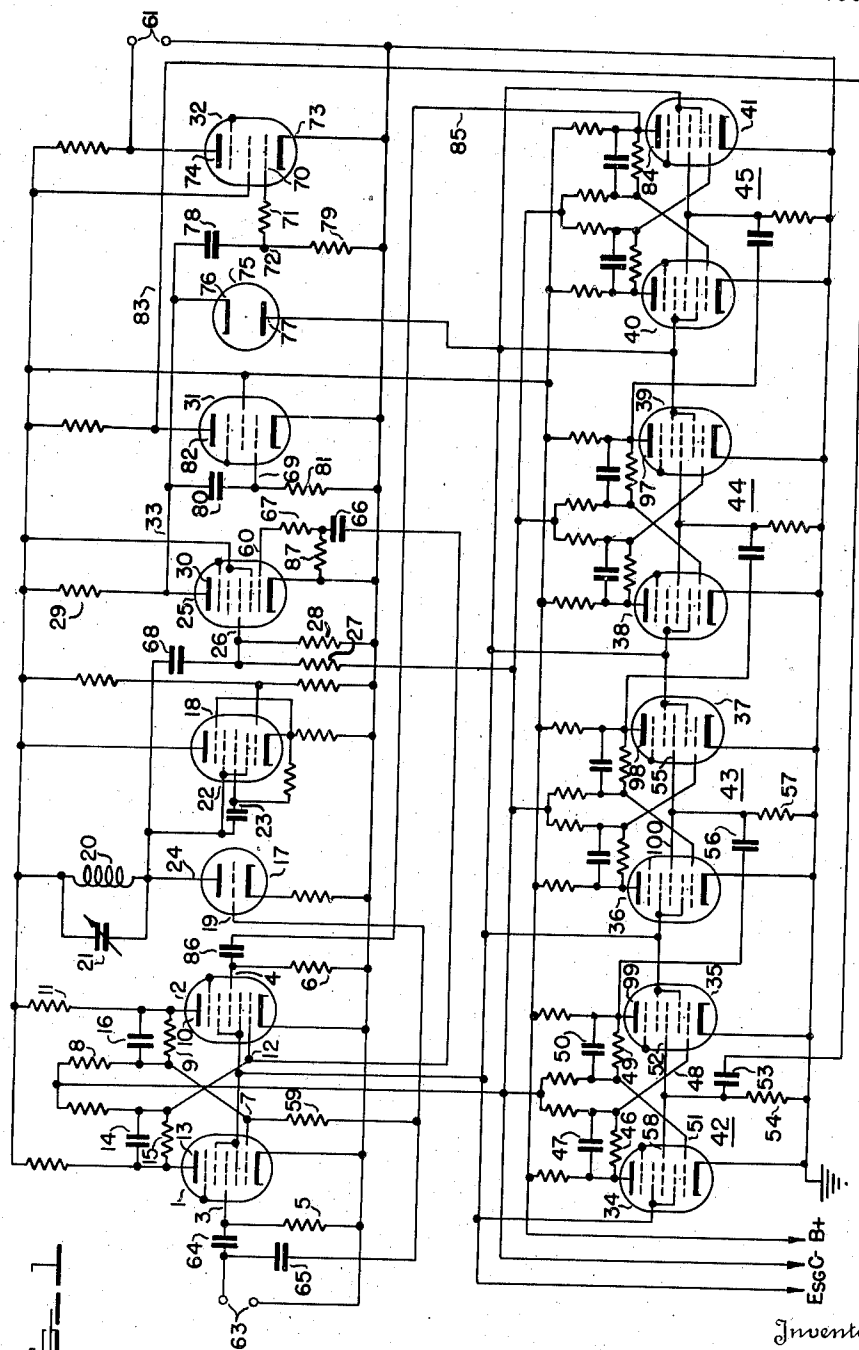
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CONTROLLABLE PULSE GENERATOR

Filed May 22, 1945

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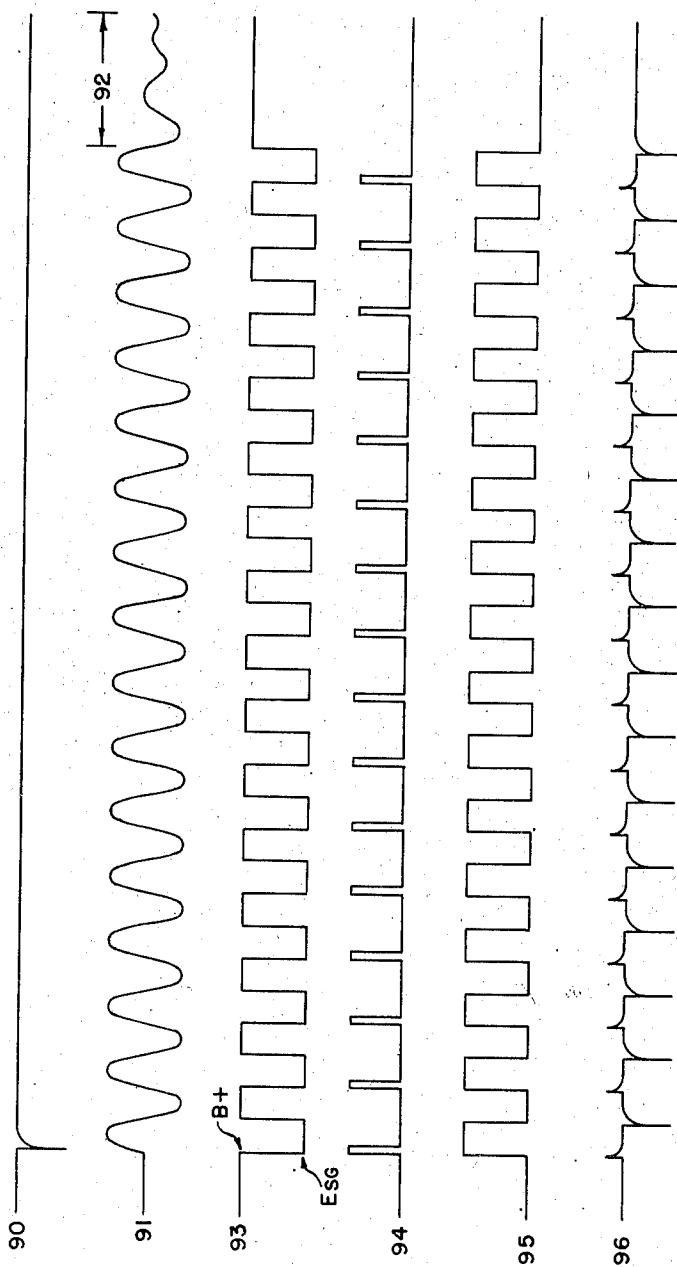
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FIG. 2



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CONTROLLABLE PULSE GENERATOR

Harold Lyons, Washington, D. C.

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7 Claims. (Cl. 250—27)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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This invention relates in general to electronic pulse generators and in particular to a controllable electronic generator of pulses having definite predetermined and stable characteristics.

In certain electronic developments, of which radio, radio detection and television are notable, timing requirements are so critical and control sensitivity requirements so high that controlled on-off operation of certain component circuits is extremely difficult. Many circuits, which operate in a stable fashion after equilibrium conditions have been reached, have periods of instability which accompany the initiation and arrest of their functions. These periods of instability may be marked by such characteristics as time delays, transients voltage and frequency variations. Other circuits, while well adapted to on-off operation, may fall short of required performance characteristics under normal operating conditions. In either case, a compromise is involved and some sacrifice in over-all performance must be made to allow for such shortcomings.

It is an object of this invention to provide a controllable, stable electronic pulse generator.

It is another object of this invention to provide a pulse generator adaptable to switched operation the output of which is uniform with respect to frequency, amplitude, time duration, time spacing and rate of change.

It is another object of this invention to provide a pulse type generator operative only upon application of an external signal and then operative in such a manner as to introduce no time delay between the generation of the initial pulse and the external signal.

It is another object of this invention to provide a generator of electrical impulses which suppresses from its output any transient oscillations occurring within said generator after the arrest of its normal function.

It is another object of this invention to provide an electronic pulse generator which has inherent power to render itself inoperative after the generation of a selectable number of pulses.

It is another object of this invention to provide a constant frequency pulse generator.

It is another object of this invention to provide a pulse generator the frequency of which may be controlled by ordinary tuning methods.

Other objects and features of this invention will become apparent upon a careful consideration of the following detailed description when taken together with the accompanying drawings in which:

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Fig. 1 is the circuit diagram of one embodiment of this invention and;

Fig. 2 is a series of waveforms used in explaining the operation of the circuit shown in Fig. 1.

Reference is now had in particular to Fig. 1 wherein there is shown one form of a controllable pulse generator constructed according to the teachings of this invention. Tubes 1 and 2 represent the multi-grid vacuum tube components of a circuit which is capable of maintaining either one of two stable states of equilibrium but which has no inherent power of action. It can, in the manner described below, be caused to switch from one state of equilibrium to the other by the application of suitable electrical impulses to second control grids 3 and 4. Second control grids 3 and 4, by virtue of their connection to ground through respective resistances 5 and 6 place no restriction upon the flow of plate current in tube 1 and 2 except upon application to them of negative triggering pulses. Thus they do not function to maintain either of the two equilibrium states of the circuit but serve merely as triggering grids. First control grid 7 of tube 1 is so connected to negative C— voltage through resistance 8 and to anode 10 of tube 2 through resistance 9, however, that it assumes a negative potential which renders tube 1 non-conducting when tube 2 is conducting and anode 10 is below B+ potential by the amount of the voltage drop across resistance 11. When tube 2 is non-conducting and anode 10 is at substantially B+, grid 7 assumes a potential which permits the free flow of plate current in tube 1. Grid 12 is similarly connected to C— potential and anode 13 of tube 1 in such a fashion that it assumes cutoff potential when tube 1 is conducting and, in the other state, renders tube 2 conducting when tube 1 is cutoff. Thus one state of equilibrium corresponds to tube 1 conducting and tube 2 non-conducting and is the state which exists during the quiescent non-operative condition of the generator circuit of Fig. 1. The other state of equilibrium corresponds to tube 1 non-conducting and tube 2 conducting and is the state which exists during the operative condition of the pulse generator. The electronic switch represented by tubes 1 and 2 may be caused to change rapidly from one state to the other by the application of a negative pulse to grid 3 of tube 1 if it is conducting or to grid 4 of tube 2 if it is conducting. Such triggering pulses cut off plate current flow momentarily in the tube to which applied and cause an amplified positive signal to appear at its anode. This positive signal communicated to either grid 7 or grid 12

as the case may be initiates the regenerative action which characterizes such switching circuits and the change in state takes place. Compensating capacitors 14 and 16, in shunt with resistors 15 and 9 respectively, serve to hasten the change of state since they, in effect, bypass resistors 15 and 9 during the short period of transition. It will be seen that grids 7 and 12 alternate between two different voltage levels as the electronic switch changes states and that these voltage levels may be utilized to control functions coincident with one or the other states of the electronic switch.

Triode vacuum tube 17 represents a switch tube and multigrid vacuum tube 18 the negative resistance tube of a switched transitron oscillator of the type described in copending application entitled "Calibrating apparatus" Serial No. 537,286 filed May 25, 1944 by La Verne R. Philpott. When grid 19 is at such a potential that no current flows through tube 17, the mode of operation of the circuit comprising tube 18 and associated components including the high "Q" parallel resonant circuit of inductance 20 in shunt with capacitance 21 is that of a transitron oscillator. In the form shown, advantage is taken of the negative transconductance between screen 22 and second control grid 23 to supply the power to support continuous oscillation in the parallel resonant circuit. Such oscillation, which appears at anode 24 of tube 17, takes the form of a sine wave free from harmonics and of a constant frequency which is the resonant frequency of the tank circuit comprising inductance 20 and capacitance 21. While this frequency is constant for any given operating condition, it may be varied by changing the resonant frequency of the tank circuit. This may conveniently be done by ordinary tuning means such as adjustment of variable capacitor 21.

It is the function of tube 17 when conducting to provide a low resistance path across the tank circuit to ground and to thereby prevent the existence of oscillations. It is also the function of tube 17 when conducting to conduct an amount of current from anode 24 to ground and hence from B+ through inductance 20 to ground equal to the maximum current which flows in inductance 20 in the same direction during such times as tube 17 is cutoff and stable oscillations exist in the tank circuit. Such maximum current flow in that same direction exists during that instant of the cycle when capacitor 21 starts to charge in such a direction as to render anode 24 positive. Since this corresponds to zero phase in the oscillatory cycle, it will be seen that the current fixing function of tube 17 serves to establish the conditions under which the initial oscillation at anode 24 upon arrest of current flow in tube 17 will start at zero phase and reach the same positive amplitude as all succeeding cycles.

Tube 25, possessing sharp cutoff characteristics, represents the vacuum tube component of a conventional amplifier in which grid 26 by virtue of its connection to C- through resistance 27 and ground through resistance 28 biases the tube to cutoff so that it operates class B. Thus, negative signals applied to grid 26 only increase the bias below cutoff while positive signals cause plate current flow through resistance 29 in such a fashion as to cause such positive signals to appear amplified and inverted at anode 30.

Tubes 31 and 32 represent unbiased amplifier stages which have a common input lead 33. In the case of tube 31, clamping action of the low

grid-cathode resistance causes a charging of capacitance 80 in the interval between negative pulses produced at the anode 30 of tube 25 with the result that substantially the entire negative pulse produced at 30 is applied as a negative pulse to grid 69.

In the case of tube 32, coupling circuit 78-79 is of the short time-constant variety producing a differentiation of the pulses in line 33. This differentiating action produces at point 72, alternate negative and positive "spike" pulses of equal amplitude, having ground as an average potential. Grid current flows in tube 32 during the positive "spikes" with the result that, due to the limiting resistance 71, the amplitude of the positive spikes as applied to the grid 70 is attenuated. Thus these positive signals occurring at point 72 cause negligible rises in grid 70 above cathode 73 and therefore cause negligible change at anode 74 of tube 32. Both tube 31 and tube 32 amplify and invert negative signals appearing at respective grids 69 and 70. When the amplitude of such negative signals is great enough to cause the grid bias to exceed cutoff, the amplified and inverted signals appearing at anodes 74 and 82 are also plate circuit limited.

Vacuum tube diode 75 is a limiting tube disposed between lead 33 and Esg screen grid voltage supply. The connection of cathode 76 to lead 33 and anode 77 to Esg requires that anode 30 of tube 25 be reduced in potential from B+ potential to Esg potential by flow of plate current through resistance 29 before tube 75 is rendered conducting. The low resistance of diode 75 when conducting functions to fix Esg as the lowest voltage which can exist at lead 33 and hence at anode 30.

Tubes 34, 35, 36, 37, 38, 39, 40 and 41 represent the vacuum tube components of a scale of sixteen type of counter circuit. This circuit comprises four conventional type of scale-of-two counter stages 42, 43, 44 and 45, connected in cascade. The first stage 42 consists of multigrid vacuum tubes 34 and 35, connected so that the output from tube 34 is coupled through resistance 46 shunted by capacitor 47 to first control grid 48 of tube 35, while the output of tube 35 is coupled through resistance 49 shunted by capacitor 50 to first control grid 51 of tube 34. In succeeding counter stages 43, 44, and 45, the corresponding tube elements are connected in the same manner as in first stage 42. In this way each stage is directly connected in a regenerative manner, similar to the manner employed in the electronic switch comprising tubes 1 and 2, so that one tube in each stage will be conducting and the other tube non-conducting and in which condition the stage will remain until there is applied to it some external signal or trigger. Whereupon this trigger will be regeneratively amplified until the conditions of the stages are reversed. The input to the first stage 42 is applied in parallel to second control grids 58 and 52 of tubes 34 and 35 through a low time constant circuit consisting of condenser 53 and resistance 54 while the input to second stage 43 is obtained from anode 99 of tube 35 and is applied in parallel to second control grids 100 and 55 of tubes 36 and 37 through a low time constant circuit consisting of condenser 56 and resistance 57. The function of this coupling circuit is to apply to second control grids 100 and 55 of second stage 43 a negative pulse each time tube 35 passes from non-conduction to conduction and a positive pulse each time it passes from conduction to non-conduction. Similarly third stage 44 receives its in-

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put from tube 37 of second stage 43 and fourth stage 45 receives its input from tube 39 of third stage 44.

By constructing a counter circuit with multi-grid tubes arranged as shown, each stage is made to respond only when a negative impulse is applied to its second control grids, so a total of sixteen negative impulses are required at the input to first stage 42 to cause the counter circuit to pass through a complete cycle of operation. If the counter circuit is in the state in which all right hand tubes are conducting tube 41 will be rendered non-conducting at the end of the eighth pulse and then conducting again at the end of the sixteenth pulse applied to the first stage second control grids 58 and 52.

The quiescent or non-operative state of the pulse generator of Fig. 1 is characterized by the following conditions to which the generator returns after each complete cycle of operations; tube 1 of the electronic switch is conducting and tube 2 therefore non-conducting; tube 17 is conducting by virtue of its grid 19 connection through resistor 59 to grid 7 of tube 1; the transitron oscillator is inoperative because of the conduction of tube 17; tube 25 is quiescent since its input signals originate from the anode 24 of tube 17 which is quiescent; tubes 31 and 32 are likewise quiescent since they receive their signals through common lead 33 from anode 30 of tube 25; tube 75 is non-conducting since anode 30 of tube 25 is at B+; the counter circuit is quiescent since it receives its input signals from the anode of tube 31 which is quiescent; all left hand tubes 34, 36 and 38 and 40 of the counter circuit are in the non-conducting state; and no signal appears at output terminals 61 since such signals originate at anode 74 of tube 32 which is quiescent.

The generator is rendered operative by the application of a negative signal at input terminals 63 of the electronic switch from an external source not shown. If the pulse generator were a component part of a radar or television equipment, for example, in which the start of the pulse generator were required in synchronism with other operations, the negative signal might originate from a master timer. If timing requirements were critical this negative signal would have an abrupt leading edge, i. e., it would take the form of a sharp pulse so as to institute its triggering function with a minimum of delay. The magnitude of the triggering signal applied at input 63 need only be such that, when applied to second control grid 3 of tube 1 through coupling capacitor 64, the regenerative switching action of the electronic switch is instituted and such that, when applied to grid 19 of tube 17 through capacitor 65, the flow of current through tube 17 is cutoff sharply. While it is true that tube 17 is also cut off by the reduction in potential at grid 7 communicated to grid 19 through resistance 59 coincident with the switching action of tubes 1 and 2, there does occur some time delay in said switching action. This time delay, however, is short enough to allow the switching action to occur and the potential at grid 7 to drop sufficiently to hold tube 17 cut off before the decay of the original triggering signal applied to grid 19 through capacitor 65. This complementary action serves to initiate the operation of the transitron oscillator coincident with the leading edge of the signal applied at input 63 and the electronic switch merely supplies the negative potential at grid 19 which maintains the oscilla-

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tor operation without also introducing the switching time delay. It will be seen that the switching action which renders tube 2 conducting causes a positive change in potential at grid 12. This positive change, communicated to grid 60 of tube 25 through capacitor 66 and resistance 67 is rendered impotent by the grid limiting action of resistance 67 as grid 60 undertakes to rise above its quiescent cathode potential.

In the manner hereinbefore described, the abrupt cutoff of tube 17 causes the transitron oscillator, represented by tube 18, inductance 20, capacitance 21, and associated components, to generate a sinusoidal voltage which starts at zero phase, proceeds in a positive direction on the initial excursion and reaches maximum stable operation amplitude on the first half cycle of the sine wave. This sine wave, of a frequency tunable by adjustment of the parameters of the parallel resonant circuit in screen grid 22 lead to tube 18, is applied through capacitor 68 to second control grid 26 of tube 25. Tube 25, being biased to cutoff is unresponsive to the negative half cycles of the sine wave but amplifies and inverts the positive half cycles. There tends to appear an anode 30 of tube 25 a series of amplified negative half sine wave cycles but this tendency is limited by the fact that the drop in potential at anode 30 is limited by the conduction of tube 75. Therefore, there actually appears at anode 30 of tube 25 a series of substantially rectangular negative pulses each spaced in time one half period of the frequency of the transitron oscillator. Each such rectangular negative pulse is of an amplitude equal to the drop from B+ to Esg, each is equal in time duration to the half period of the transitron oscillator and the leading edge of the initial rectangular pulse is disposed in time coincident with the leading edge of the input trigger applied to terminals 63.

This series of negative rectangular pulses appearing at anode 30 is communicated by lead 33 to the coupling circuit of tube 32 comprising capacitor 78 and resistance 79. The time constant of this coupling circuit is short compared to the duration of the negative pulse so that it acts as a peaker or differentiator. By virtue of this peaker action, there appears at point 72 a sharp narrow negative pulse coincident with the leading edge and a sharp narrow positive pulse coincident with the trailing edge of each rectangular pulse appearing at anode 30 of tube 25. The narrow positive pulses are impotent through the limiting action of resistance 71 while the narrow negative pulses drive grid 70 below cutoff potential causing plate circuit limiting. There therefore appears at anode 74 and hence at output terminals 61 a series of narrow rectangular positive pulses equally spaced in time of equal time duration, and with the initial pulse of the series having a leading edge coincident with the leading edge of the trigger signal applied at input 63.

The same rectangular pulses which reach tube 32 through lead 33 also are applied to tube 31 through the coupling circuit comprising capacitor 80 and resistance 81. The time constant of this coupling circuit is long compared to the rectangular pulse duration and the rectangular pulse amplitude is great compared to the change required at grid 69 to cut off plate current flow in tube 31 so that there appears at anode 82 a series of plate circuit limited rectangular positive pulses of time duration equal to those of opposite polarity appearing at anode 30 of tube 25. Lead

83 communicates these positive pulses to the input of first counter stage 42. When applied to the low time constant circuit comprising capacitor 53 and resistance 54, each rectangular positive pulse is resolved into a sharp positive pulse coincident with the leading edge and a sharp negative pulse coincident with the trailing edge of such rectangular pulse. As hereinbefore explained, the sharp positive pulses do not affect the trigger circuit. Each sharp negative pulse, however, causes a different state to exist in the circuit until sixteen such negative pulses complete the counter cycle and all left hand tubes are again rendered non-conducting and all right hand tubes, including tube 41 are rendered conducting. The transition of tube 41 from a non-conducting to a conducting condition which corresponds to the trailing edge of the sixteenth pulse appearing at the plate of tube 31 causes a drop in potential of anode 84. This drop in potential, communicated to grid 4 of tube 2 through lead 85 and the low time constant circuit comprising capacitor 25 and resistance 6 triggers the electronic switch back into the state corresponding to the non-operative condition of the pulse generator. The switching of tubes 1 and 2 into conduction and non-conduction respectively causes an increase in potential of grid 7 and a decrease in potential of grid 12. The increase registered at grid 7 appears also at grid 19 of tube 17 shunting the resonant tank circuit 20 and 21 with a low resistance path so that the transitron oscillator is rendered inoperative. The decrease registered at grid 12 is applied to grid 30 of tube 25 through the coupling circuit comprising capacitor 66 and resistance 37. The time constant of this coupling circuit is such, with respect to the amplitude of the change appearing at grid 12, that capacitor 66 is charged to the potential which allows conduction by tube 25 only after all transient oscillations in the transitron circuit resulting from abrupt arrest of function have been damped out. Tube 25 is returned to a conducting condition as soon as capacitor 66 becomes fully charged but it has, during the transition period following the switching off of the pulse generator, suppressed from output 61 the transient oscillations which would be registered on any circuit responsive thereto which might be coupled to such output.

Reference is now had to Fig. 2 in which are shown waveforms representative of certain of the voltage variations appearing within the pulse generator during a cycle such as that described above. Waveform 90 is representative of the trigger pulse applied to input terminal 63 to initiate the operation of the pulse generator. Waveform 91 represents the sine wave produced by the transitron oscillator appearing at anode 24 of tube 17. It will be noted that, since the negative signal of waveform 90 is applied to tube 17 as well as to the electronic switch that the transitron starts without time delay and the first half cycle which is positive, starts from zero phase and has the amplitude which the oscillator output assumes under continuous operating conditions. It will also be noted that transient oscillations taking the general form of waveform 91 at 92 occur after tube 17 is rendered conducting as outlined above. Waveform 93 is representative of the rectangular negative pulses appearing at anode 30 of tube 25. The amplitude of these negative pulses is limited by the screen grid voltage E_{sg} . E_{sg} is so chosen with respect to the B+ supply that the amplitude of such

negative pulses includes only the initial, abrupt rise of the half sine wave pulses which would appear at anode 30 if it were not for diode tube 75. At the same time, these negative pulses are of sufficient amplitude to drive tubes 31 and 32 well below cutoff as hereinbefore explained. Waveform 94 is representative of the narrow positive pulses appearing at anode 74 of tube 32 and hence at output 61 of the pulse generator. It will be noted that the pulses of waveform 94 are of equal time duration, equal time spacing, uniform amplitude, that the leading edge of the initial pulse coincides in time with the trigger pulse of waveform 90, and that the transient oscillations 92 of waveform 91 do not appear at output 61. Waveform 95 represents the positive pulse output of tube 31 which is differentiated into the peaked pulses of waveform 96 by coupling capacitor 53 and resistance 54.

By comparison of waveforms 94 and 96, it will be seen that the sixteenth negative pulse of waveform 95, which renders tube 41 of the counter circuit conducting and thereby triggers the electronic switch into the non-operative condition of the generator, is disposed in time approximately one-half of the transitron oscillator after the appearance of the sixteenth positive pulse at output 61 and approximately one-half period before the time when the seventeenth positive pulse would have appear at output 61. Since it is desired to produce sixteen and only sixteen positive pulses at output 61, the approximate half period between the application of the sixteenth negative pulse of waveform 96 to the counter and the time when the seventeenth positive pulse would have appeared at the output is provided to negate any time delay introduced by the counter circuit and by the electronic switch.

It will be evident that the sixteen pulse group generated by the embodiment of this invention as connected in the diagram of Fig. 1 could have been an eight pulse group if lead 85 had been connected to anode 97 of third stage 44 of the counter circuit, that it could have been a four pulse group if lead 85 has been connected to anode 98 of second stage 43, and a two pulse group if connected to anode 99 of first stage 42. Likewise the generator becomes a single pulse generator if the output of tube 31 is coupled to grid 12 of tube 2. The type of counter employed, provided the time delay it introduced did not exceed the half period limit hereinbefore described, is not a limiting feature of the invention. For example, a fully integrated scale of 32 counter with a suitable 32 position switch would permit the selection of any pulse group number from 1 to 32. It is possible to make certain substitutions in vacuum tubes employed without exceeding the limits of the invention. For examples, a pentode may be used in place of multigrid tube 18 of the transitron oscillator and a triode may be used in place of the pentode amplifier tube 31.

Since certain further changes may be made in the foregoing constructions and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter shown in the accompanying drawings or set forth in the accompanying specification shall be interpreted as illustrative and not in a limiting sense.

The invention described herein may be manufactured and used by or for the Government of the United States of America for Government purposes without the payment of any royalty thereon or therefor.

What is claimed is:

1. A method of producing a controlled number of voltage pulses, which comprises first generating a sine wave voltage, transforming said sine wave voltage into a rectangular voltage wave of the same frequency as said sine wave voltage, subjecting said rectangular voltage wave to differentiation, eliminating from said differentiated rectangular wave the voltage pulses of one sense, so as to produce an output consisting of a series of equally time spaced pulses of one voltage sense, electronically counting the number of cycles in said sine wave and abruptly terminating the generation of said sine wave voltage when the number of said output pulses reaches a predetermined count.

2. A method of producing a controlled number of voltage pulses, which comprises generating a sine wave voltage of uniform maximum amplitude in response to an input signal, causing said sine wave voltage to start at zero phase coincident with said input signal and reach said maximum amplitude on the first excursion, generating a rectangular voltage wave by transforming said sine wave voltage, subjecting said rectangular voltage wave to differentiation, eliminating from said differentiated rectangular wave the voltage pulses of one sense so as to produce an output consisting of a series of equally time spaced pulses of one voltage sense, electronically counting the number of cycles in said sine wave and abruptly terminating the generation of said rectangular voltage wave when the number of said output pulses reach a predetermined count.

3. A means for producing a regularly recurrent and controllable number of voltage pulses, comprising a sine wave oscillator, an electronic switch connected to said oscillator and adapted to set the latter into operation in response to an input signal applied to said electronic switch, means for transforming the sine wave output of said oscillator into a series of equally time spaced output pulses, and an electronic counter circuit interconnecting said last named means and said electronic switch in such a manner that, upon the generation of a predetermined number of cycles by said oscillator, said counter circuit will operate to actuate said electronic switch to thereby stop said oscillator.

4. A means for producing a regularly recurrent and controllable number of voltage pulses of selectable frequency, comprising a sine wave oscillator, an electronic switch connected to said oscillator and adapted to set the latter into operation in response to an input signal applied to said electronic switch, means for transforming the sine wave output of said oscillator into a series of output pulses with equal time spacing, means for selecting the frequency of said oscillator so as to thereby alter said time spacing, and an electronic counter circuit interconnecting said sine wave transforming means and said electronic switch in such a manner that, upon the generation of a predetermined number of cycles by said oscillator, said counter circuit will operate to actuate said electronic switch to thereby stop said oscillator.

5. A means for producing a regularly recurrent pulse signal, comprising a sine wave oscillator, a vacuum tube switching means connected to said oscillator and adapted to turn the latter off and on, an electronic switch connected to said vacuum tube switch and adapted to control the operation of the latter, said electronic switch being held re-

sponsive to an input signal applied thereto and operating to maintain said vacuum tube switch in either of two conditions whereby said oscillator will be held either quiescent or operative, means coupling an input signal applied to said electronic switch to said vacuum tube switch to negate any time delay occurring in said electronic switch, means for transforming the sine wave output of said oscillator into a series of equally time spaced output pulses, and an electronic counter circuit interconnecting said last named means and said electronic switch in such a manner that, upon the generation of a predetermined number of cycles by said oscillator, said counter circuit will operate to actuate said electronic switch and thereby stop said oscillator.

6. A means for producing a regularly recurrent pulse signal comprising a sine wave oscillator, a vacuum tube switching means connected to said oscillator and adapted to turn the latter off and on, an electronic switch having two distinct states connected to said vacuum tube switch and adapted to control the operation of the latter, said electronic switch being held responsive to an input signal applied thereto and operating to maintain said vacuum tube switch in either of two conditions corresponding to said two distinct states whereby said oscillator will be held either quiescent or operative, means coupling an input signal applied to said electronic switch to said vacuum tube to negate any time delay occurring in said electronic switch, means responsive to said electronic switch adapted to suppress from the output any pulses for a period of time subsequent to the initiation of one of said states of said electronic switch, means for transforming the sine wave output of said oscillator into a series of equally time spaced output pulses, and an electronic counter circuit interconnecting said last named means and said electronic switch in such a manner that, upon the generation of a predetermined number of cycles by said oscillator, said counter circuit will operate to actuate said electronic switch and thereby stop said oscillator and suppress from the output any pulses for a period of time.

7. A means for producing a regularly recurrent pulse signal of selectable frequency, comprising a sine wave oscillator, a vacuum tube switching means connected to said oscillator and adapted to turn the latter off and on, an electronic switch having two distinct states connected to said vacuum tube switch and adapted to control the operation of the latter, said electronic switch being held responsive to an input signal applied thereto and operating to maintain said vacuum tube switch in either of two conditions corresponding to said two distinct states whereby said oscillator will be held quiescent or operative, means coupling an input signal applied to said electronic switch to said vacuum tube to negate any time delay occurring in said electronic switch, means responsive to said electronic switch adapted to suppress from the output any pulses for a period of time subsequent to the initiation of one of said states of said electronic switch, means for transforming the sine wave output of said oscillator into a series of output pulses with equal time spacing, means for selecting the frequency of said oscillator so as to thereby alter said time spacing, and an electronic counter circuit interconnecting said sine wave transforming means and said electronic switch in such a manner that, upon the generation of a predetermined number of cycles by said oscillator, said counter circuit will op-

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erate to actuate said electronic switch and thereby stop said oscillator and suppress from the output any pulses for a period of time.

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