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COUNTING CIRCUIT

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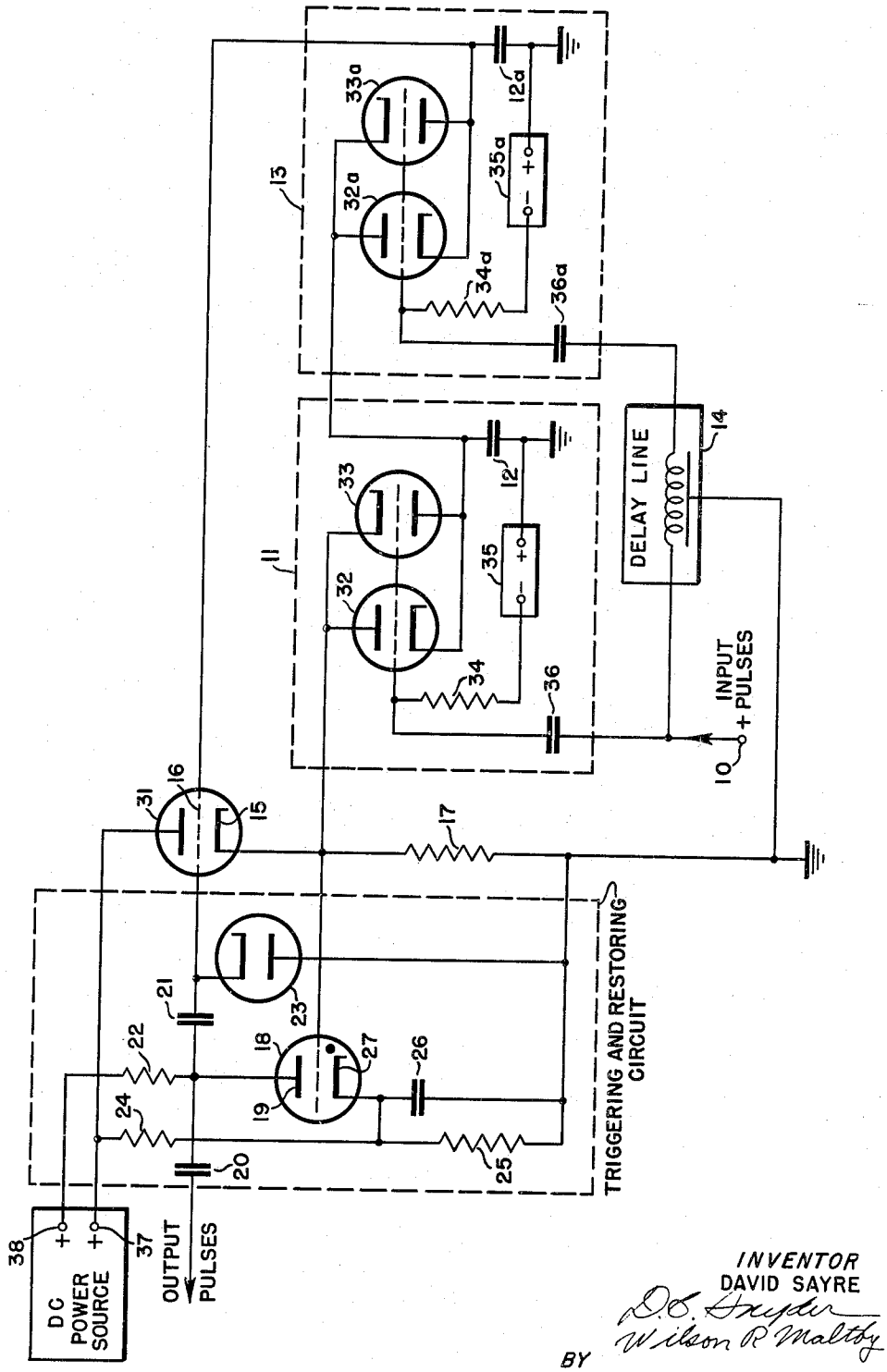

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COUNTING CIRCUIT

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12 Claims. (Cl. 250—27)

This application is a continuation-in-part of my copending application, Serial No. 635,095, filed December 14, 1945, for "Counting Circuit," now abandoned.

This invention relates to electronic control circuits and more particularly to a pulse counter incorporating a cathode follower to provide a distinct and dependable voltage step when triggered. Heretofore pulse counters were limited in application because they operated satisfactorily only when the applied pulses were of uniform size and shape. Furthermore, they tended to be unstable in their operation.

This invention contemplates the use of a cathode follower in which a triode is biased so that the cathode potential is normally at a more positive value than the control grid, and further that the control grid of the cathode follower is isolated from the cathode thereof by means of two sequentially operating electronic switches. The input pulses to be counted are applied directly to the first electronic switch and through a time delay circuit to the second electronic switch to transfer the cathode potential of the cathode follower to the control grid thereof in two successive steps while maintaining the control grid isolated from the cathode. A stepped increase of voltage at both the control grid and the cathode results in response to each input pulse to be counted.

The invention further contemplates an electron tube circuit responsive to a predetermined amplitude of cathode follower cathode potential to develop a single output pulse for a predetermined number of input pulses and a circuit for coupling the output pulse to the control grid of the cathode follower to restore potential conditions at both control grid and cathode to an initial fixed reference level.

A primary object of the present invention is to eliminate the foregoing difficulties in pulse counters.

Another and more specific object of the invention is to provide a pulse counter incorporating the use of a cathode follower to provide a dependable voltage step wave form upon the application of pulses thereto.

Another object of the invention is to provide means of counting pulses which may not be of uniform size and shape.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing which is a circuit diagram of an embodiment of the invention.

Referring to the drawing, a triode 31 is connected as a cathode follower circuit in which the plate is connected directly to the positive terminal 37 of a direct current energy source. The cathode 15 of triode 31 is connected to ground through the cathode follower load resistance 17. The operating conditions of triode 31 are selected so that triode 31 is conducting when the grid 16 of triode 31 is at ground potential, the initial reference grid potential level for the count. A small positive voltage appears across cathode follower load resistor 17 as a result of space current of triode 31, which places cathode 15 of triode 31 at a positive potential with respect to grid 16.

An incoming positive pulse applied at terminal 10 renders conductive an electronic switch, here shown as a normally nonconducting two-way double triode clamping circuit 11, the operation of which will be discussed more fully hereinafter. For a time substantially equal to the pulse duration, clamping circuit 11 connects capacitor 12 to the cathode 15 of cathode follower 31 thereby bringing capacitor 12 to substantially the same voltage as the cathode.

The two-way double triode clamping circuit 11 is a conventional clamping circuit arranged so that a negative bias is applied from D. C. source 35, for example a battery, through resistor 34, to the control grids to maintain triodes 32 and 33 normally nonconducting. A positive signal or pulse applied through coupling capacitor 36 to the control grids of triodes 32 and 33 makes it possible for triode 32 to become conducting in the event that the potential at cathode 15 is more positive than the potential existing on capacitor 12. By conduction of triode 32 the potential on capacitor 12 is made substantially equal that of cathode 15. On the other hand, in the event that the potential on capacitor 12 should become more positive than the potential at cathode 15, triode 33 is rendered conducting and capacitor 12 is discharged through triode 33 and resistor 17 to substantially the same potential as that appearing at cathode 15. As is well known in the art triodes having a low plate resistance are selected in order that the voltage drop across the clamping triode shall be a minimum.

An incoming input pulse applied at terminal 10 is also applied to delay line 14 (a suitable time delay circuit may be used) so that a short time later the same positive incoming pulse first applied to clamping circuit 11 is applied to the normally nonconducting two-way double triode clamping circuit 13 which behaves in the same manner as that described for clamping circuit 11. For the time duration of the delayed pulse, circuit 13 acts to close the circuit between capacitor 12 and capacitor 12*a* which is also connected to the grid 16 of cathode follower 31. It will be understood that delay line 14 provides a delay less than the time interval between incoming pulses but of sufficient time so that the clamping circuit 11 is nonconducting at the time when clamping circuit 13 is biased to conduction or energized by the delayed pulse. This condition of operation makes it impossible for the cathode follower grid 16 to be connected directly to its cathode 15. Assuming that the grid 16 of cathode follower 31 is initially at ground potential, it is seen that the positive potential appearing across cathode follower load resistor 17 is transferred to capacitor 12 through the operation of clamping circuit 11 and subsequently is transferred through clamping circuit 13 to capacitor 12*a* thereby raising the potential of grid 16 by a definite positive voltage step. This increase in grid voltage causes the cathode follower 31 to conduct more heavily, thereby increasing the current flow through load resistor 17, thereby raising the potential on cathode 15 by a definite positive step. However, this higher cathode potential cannot affect the potential on capacitor 12 since the clamping circuit 11 is normally nonconducting nor can the potential at grid 16 and capacitor 12*a* be affected by the higher potential on the cathode 15 since clamping circuit 13 is also normally non-conducting. The next incoming pulse applied at terminal 10 again acts to transfer the potential of cathode 15 to capacitor 12 and subsequently, by the time delay of circuit 14, from capacitor 12 to capacitor 12*a* again to increase the potential of grid 16 by a definite positive step. In this manner a "staircase" or rising and stepped voltage wave form is generated both at the grid

16 and the cathode 15 of cathode follower 31 by a series of incoming pulses.

The cathode of cathode follower 31 is directly connected to the control grid of a thyratron 18 or similar trigger tube, having the anode 19 thereof returned to a positive power supply 38 through a load resistor 22. The thyratron 18 is rendered normally nonconductive by a positive potential applied to the cathode 27 by the connection thereof to the junction between resistors 24 and 25 forming a voltage divider across the cathode follower anode positive supply 37 and ground. The capacitor 26 is used to stabilize the potential across resistor 25, used to bias the thyratron.

On the voltage step which carries the cathode 15 above a certain voltage the thyratron 18 fires. The resulting current flow through the load resistor 22 causes the voltage on the anode 19 to drop to a value low enough to cut off the current flow in the thyratron 18. This rapid rise and fall of current produces a negative voltage pulse at anode 19 which is coupled to an external circuit through capacitor 20. Simultaneously, this negative voltage pulse appearing at anode 19 is applied by means of capacitor 21 to restore the voltages of the grid 16 and cathode 15 to the initial reference potential level. The diode 23 connected between control grid 16 and ground acts as a diode clamping circuit to prevent the grid 16 from being returned to a potential lower than ground when the thyratron fires, thereby establishing the aforesaid initial reference grid potential at ground potential.

It will be noted that the duration of the signal pulses to be counted must be long enough to permit complete charging of capacitors 12 and 12*a*. Likewise, it is necessary that the voltage difference between the control grid and the cathode of cathode follower 31 shall be a step of sufficient amplitude to permit positive firing of the thyratron at the desired count and to prevent firing of the thyratron at a lower count. It is also to be noted that in normal operaion the last input pulse of a counting sequence shall have a duration time so that the time of conduction of clamping circuit 13 is not only long enough for the potential on capacitor 12*a* and control grid 16 to increase the potential of cathode 15 to cause thyratron 18 to fire, but also the time of conduction of clamping circuit 13 is long enough to permit discharge of capacitor 12 as well as capacitor 12*a* to ground potential. However, if through abnormal conditions, these capacitors are incompletely discharged by the pulse applied through capacitor 21, the first incoming pulse in a new sequence applied at terminal 10 acts, for example, to render triode 33 conducting and reduces potential on capacitor 12 by discharge through triode 33 and cathode follower load resistor 17 to produce a substantial equality of potential at cathode 15 and capacitor 12.

In this manner output pulses coupled through capacitor 20 are developed at some submultiple of the applied pulses as determined by the thyratron cathode bias. The advantages of the invention are very good stability and ability to handle fast counting rates. Furthermore, the input pulses need not be of a uniform size or shape to generate the proper "staircase" wave forms.

I claim:

1. Electrical apparatus for providing an output pulse when energized by a predetermined number of input pulses, comprising a cathode follower circuit including an electron tube having at least a cathode, a control grid and an anode wherein the input signal is applied between said control grid and ground and the output signal is taken from said cathode and ground, means energized by an input pulse for raising the input potential of said cathode follower, thereby raising the potential of said cathode follower output, an electron tube biased to be normally nonconductive, said electron tube being coupled to the output of said cathode follower for producing said output pulse in response to a rise in potential of said output to a predetermined value to provide said output pulse, and means responsive to said output pulse to reduce said input potential.

2. Electrical apparatus for providing an output pulse when energized by a predetermined number of input pulses, comprising a cathode follower including an electron tube having at least a cathode, a control grid, and an anode, said cathode follower having a cathode load resistance, a first clamping circuit connected between said cathode load resistance and a second clamping circuit, a delay line, means for applying said input pulses simultaneously to said first clamping circuit and said delay line, said second clamping circuit being connected between said control grid of said cathode follower and said first clamping circuit, said second clamping circuit being energized through said delay line, an electron tube biased to be normally nonconductive and biased by said cathode follower load resistance to be operative at a predetermined potential to produce said output pulse, and means applying said output pulse to reduce the potential of said cathode follower control grid.

3. Electrical apparatus for providing an output pulse when energized by a predetermined number of input pulses, comprising a cathode follower including an electron tube having at least a cathode, a control grid and an anode, said cathode follower having a cathode load resistance, a first electron switch connected between said cathode load resistance and a second electronic switch, a delay line, means for applying said input pulses simultaneously to said first electronic switch and said delay line, said second electronic switch being connected between said control grid of said cathode follower and said first electronic switch, said second electronic switch being energized through said delay line, an electron tube biased by said cathode follower load resistance to be operative at a predetermined potential to produce said output pulse, and means operative in response to said output pulse to restore the potential of said cathode follower control grid to its initial amplitude.

4. An electrical counting circuit for providing an output pulse when energized by a predetermined number of input pulses, comprising a cathode follower circuit including an electron tube having at least a cathode, a control grid and an anode wherein the input signal is applied between said control grid and ground and the output signal is taken from said cathode and ground, means actuated by said input pulses for producing a stepped voltage wave form, wherein each of said input pulses is represented by one of said voltage steps, means applying said stepped voltage wave form to the input of said cathode follower circuit to produce a stepped voltage output from said cathode follower circuit, an electron tube circuit biased to nonconduction and responsive to a predetermined amplitude of said cathode follower circuit stepped output voltage to produce said output pulse, and means responsive to said output pulse to restore said cathode follower circuit input to its initial amplitude.

5. A counting circuit for counting pulses of varying wave forms and amplitudes, comprising a cathode follower circuit, a reference capacitor, a delay line, means responsive to each input pulse to connect said reference capacitor to the output of said cathode follower circuit for the time duration of said pulse, means applying said input pulse to said delay line to produce a secondary pulse delayed in time with respect to said input pulse, means responsive to said secondary pulse to connect the input of said cathode follower circuit to said reference capacitor for the time duration of said secondary pulse, thereby changing the amplitude of the potential of said cathode follower input by a step equal in amplitude to the difference between said cathode follower output and input potentials and hence changing said cathode follower output potential by a like amount, means operative when said cathode follower output potential reaches a predetermined amplitude to produce an output pulse, and means

responsive to said output pulse to restore said cathode follower input potential to its initial amplitude.

6. A counting circuit for counting pulses of varying wave forms and amplitudes comprising, a cathode follower circuit, a reference capacitor, a delay line, an electronic switch responsive to each input pulse to connect said reference capacitor to the output of said cathode follower circuit for the time duration of said pulse, means applying said input pulse to said delay line to produce a secondary pulse delayed in time with respect to said input pulse for a period longer than the time duration of said input pulse, a second electronic switch responsive to said secondary pulse to connect the input of said cathode follower circuit to said reference capacitor for the time duration of said secondary pulse thereby changing the amplitude of the potential of said cathode follower input by a step equal in amplitude to the difference between said cathode follower output and input potentials and hence changing said cathode follower output potential by a like amount, an electron tube biased to be nonconducting and responsive to a predetermined amplitude of said cathode follower circuit stepped output voltage to produce an output pulse, and means applying said output pulse to reduce said cathode follower input potential to its initial amplitude.

7. An electrical counting circuit for providing an output pulse when energized by a predetermined number of input pulses comprising, a cathode follower circuit including an electron tube having at least a cathode, a control grid and an anode, first and second electronic switches connected between said cathode and grid, a time delay circuit, means for applying said input pulses directly to said first electronic switch and through said time delay circuit to said second electronic switch whereby the cathode potential of the cathode follower is transferred to the grid of said cathode follower to change the potential of said grid by a step equal in amplitude to the difference between said cathode follower grid and cathode potentials, means responsive to said cathode follower cathode potential at a predetermined amplitude for producing an output pulse, and means for coupling said

output pulse to said grid to restore said grid potential to its initial amplitude.

8. Apparatus as in claim 4 in which said last-mentioned means includes a diode connected between said cathode follower control grid and ground to limit the reduction of grid potential to ground potential.

9. Apparatus as in claim 5 in which said last-mentioned means includes a diode connected between said cathode follower control grid and ground to limit the reduction of grid potential to ground potential.

10. Apparatus as in claim 6 in which said last-mentioned means includes a diode connected between said cathode follower control grid and ground to limit the reduction of grid potential to ground potential.

11. Apparatus as in claim 7 in which said last-mentioned means includes a diode connected between said cathode follower control grid and ground to limit the reduction of grid potential to ground potential.

12. An electrical counting circuit for providing an output pulse when energized by a predetermined number of input pulses comprising, a cathode follower having a load impedance in its cathode circuit, a first capacitor connected in the grid circuit of said cathode follower, a second capacitor, a normally open switch for connecting said second capacitor across said load impedance in response to an input pulse, means for applying the potential of said second capacitor to said first capacitor before the arrival of the next input pulse and at a time when said switch is open, and means connected to the output of said cathode follower adapted to produce an output pulse in response to a predetermined amplitude output of said cathode follower.

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