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PULSE FORMING NETWORKS

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[Diagram of pulse forming network with labeled components]

FIG. 1

FIG. 2

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This invention relates generally to the formation of electrical impulses and more particularly to a pulse forming network suitable for driving a glow-discharge counting tube.

A most convenient device for counting electrical impulses is the multi-stable glow discharge tube. By way of example, the 12AX7 tube of this type, such as the GC108 manufactured by Ericscon Telephones, Ltd., comprises ten equally spaced cathodes arranged in a circle about an axially positioned anode, the count being determined according to the position of the glow on one of the cathodes. To transfer the glow from one cathode to another, thereby changing the count, a pair of transfer electrodes, generally referred to as guides, are interposed between each pair of adjacent cathodes.

It is an object of this invention to provide a more simple, reliable, and highly efficient network for suitably energizing the guides of a glow discharge counting tube.

It is another object of this invention to provide a network for forming two distinct voltage pulses in response to a single input voltage pulse.

It is a further object of this invention to provide a pulse forming network wherein two voltage pulses of substantially the same duration and amplitude are formed, the leading edge of the second pulse coinciding with the trailing edge of the first pulse in point of time.

The novel features of this invention, together with further objects and advantages thereof, will be more readily understood when considered in connection with the accompanying drawing, in which:

Fig. 1 is a schematic diagram of the pulse forming network of this invention, in combination with a multi-stable glow discharge device; and

Fig. 2 is a rectilinear diagram depicting the pulses formed by the network of Fig. 1.

Referring now to Fig. 1, there is illustrated a counting tube 11, having an anode 12 and three cathodes, 13, 14, and 15. Also included in tube 11 are transfer electrodes or guides 21 through 26, inclusive. It is the function of these guides to transfer the glow from one cathode to another when suitably energized. In the event the guides are energized three times, the glow will also be transferred three times, such as from cathode 15 to cathode 14, from cathode 14 to cathode 15, and from cathode 15 back to cathode 13. To this end alternate ones of guides 21 through 26 are internally connected to one another. If tube 11 were provided with a greater number of cathodes and guides, as in the case of the decade counting tube previously mentioned, the guides would be connected in like manner and the operation of the tube would be essentially the same. The guides 21—26 are positioned in guides 21 to 26 as shown, a pulse forming network 31 for suitably energizing guides 21 through 26. Network 31 includes a dual triode electron discharge device such as a 12AX7 tube having an anode 32, a cathode 33 and a control electrode 34 in a first section 35, and an anode 36, a cathode 37 and a control electrode 38 in a second section 39; anodes 32 and 36 being connected to guides 24 and 25, respectively. Also coupled to network 31 is a power source, now shown, which provides voltages of approximately +35 v., —140 v. and —150 v. at terminals 41, 42 and 43, respectively, with reference to a ground 44. In the manner in which triode sections 35 and 39 of network 31 are interconnected with the source is as follows. Anodes 32 and 36 are connected to terminal 41 through anode resistors 51 and 52, respectively. Cathodes 33 and 37 are connected to terminal 42. Finally, control electrodes 34 and 38 are connected to terminal 43 by means of resistors 53 and 54, respectively, each of which comprises a portion of a differentiating circuit. The remainders of the respective differentiating circuits consist of capacitors 55 and 56, respectively; capacitor 55 being connected from control electrode 34 and ground 44, at terminal 45, and capacitor 56 being connected from control electrode 38 to anode 32.

In operation, the network of this invention forms a pair of negative voltage pulses to lower in sequence the potential of a pair of adjacent guides of tube 11. By properly relating the times of occurrence of these pulses, it will be seen that a transfer of the glow from one cathode to the next is thereby effected. Assuming that the glow exists on cathode 13 of tube 11, and an input voltage 61 is applied between input terminal 45 and ground 44, input voltage 61 will be impressed on the control circuit of triode section 35 in differentiared form as shown at 62. Although the waveform of input voltage 61 is relatively unimportant, for the purpose of the specific embodiment of this invention illustrated in Fig. 1, it is important that voltage 61 is at least equal to approximately 20 volts. This is because a bias voltage of approximately 10 volts is provided in this embodiment, and the input voltage, as applied to the control circuit of triode section 35 should be sufficient to drive the anode current of triode section 35 to saturation. Accordingly, the potential of anode 32 and of guide 22 will be momentarily decreased, there being in effect a negative pulse 63 applied between guide 22 and ground 44. As a result, the glow is attracted to guide 22, and moves away from cathode 13 toward the right of Fig. 1.

The negative voltage pulse 63 derived from the anode circuit of triode section 35 is also differentiated by capacitor 56 and resistor 54, and then impressed on the control circuit of triode section 39, as shown at 64. Since triode section 39 is biased closely to cut-off, the positive portion of waveform 64 may be neglected. The positive portion, however, causes an increasing amount of anode current to flow in triode section 39 until saturation is reached, thereby momentarily decreasing the potential of anode 36 and of guide 23. Thus, in effect, a negative pulse 65 is applied between guide 23 and ground 44, so as to draw the glow further from cathode 13 and nearer to cathode 14. With the cessation of pulse 65, the glow will be completely transferred to cathode 14.

The purpose of connecting anodes 32 and 36 through resistors 51 and 52, respectively, to a point of positive potential at terminal 41 is to maintain the potential of the guides 21—26 positive with respect to ground during the time that no input voltage is present. In this way, the guides are effectively disabled. It has been determined, however, that in the case of certain types of counting tubes, such as the GC108, the guides assume a positive potential during this time without an external bias being applied thereto. In addition there is sufficient cur-
rent flow between the anode 12 and the guides 21—26 of the counting tube 11 to operate triode sections 35 and 39 when an input signal occurs, the anode circuit of the counting tube and the anode potential thereof serving as the anode resistance-anode potential, respectively, of the triode sections 35 and 39. It is desirable therefore to eliminate anode resistors 51, 53, and terminal 41 from the network 31 in this case, thereby simplifying the power supply associated with the network. Also, the amount of power required to operate the network will be significantly reduced, since much less power will be dissipated in the anode circuits of the triode sections.

Fig. 2 illustrates in greater detail the forms of pulses 63 and 65 and their relative times of occurrence as determined by the time constants of the differentiating networks. Where closely adjacent, the lines defining pulses 63 and 65 actually coincide since the time constant of resistor 54 and capacitor 56 has a value equal to or somewhat less than the value of the time constant of resistor 53 and capacitor 55. As shown, there is a slight separation between the solid and dotted lines for clarity of the drawing. If the trailing edge of pulse 63 and the leading edge of pulse 65 did not substantially coincide or overlap, it will be seen that when a second input voltage occurred, the glow would be first attracted to guide 24 by pulse 63, but would then fall back on cathode 14 before pulse 65 began. Consequently, when pulse 65 did begin, the glow would be attracted by guide 23 rather than by guide 25, and would once again fall back on cathode 14 after pulse 65 ceased. By means of the network of this invention, however, the glow is transferred to cathode 15 in response to a second input voltage, and thence back to cathode 13 in response to a third input voltage.

Although a dual triode electron discharge device such as a 12AX7 is presently preferred for use in the pulse forming network of the invention, because of its compactness, separate triodes, including transistors, might also be used. In this case, it is apparent that different supply voltages may be required. Obviously, various modifications of this nature, within the spirit and scope of the invention, will occur to those skilled in the art.

Therefore what is claimed is:

1. A system for counting and visually indicating counts of electrical pulses, said system comprising a multi-stable glow discharge device having a plurality of cathode circuits and a pair of guide electrodes for each of said cathode circuits, a source of voltage to produce a glow discharge in one of said cathode circuits, and a pulse forming network alternately to decrease the potential of the guides in each of said pairs upon the occurrence of individual ones of said electrical pulses thereby successively to transfer the glow from one of said cathode circuits to another, said pulse forming network including first and second triode discharge devices each having an anode circuit and a control circuit, first and second differentiating circuits coupled to the control circuits of said first and second triodes, respectively, means for impressing individual ones of said electrical pulses on said first differentiating circuit momentarily to increase the current flow in the anode circuit of said first triode, means for deriving a first negative voltage pulse from the anode circuit of said first triode, means for impressing said first negative pulse on one of the guides in each of said pairs momentarily to lower their potential and on said second differentiating circuit momentarily to increase the current flow in the anode circuit of said second triode, means for deriving a second negative voltage pulse from the anode circuit of said second triode, and means for impressing said second negative pulse on the other of the guides in each said pair momentarily to lower their potentials subsequent to the first-mentioned ones of said guides.

2. A system for counting and visually indicating counts of electrical pulses, said system comprising a multi-stable glow discharge device having a plurality of cathode circuits and a pair of guide electrodes for each of said cathode circuits, a source of voltage to produce a glow discharge in one of said cathode circuits, and a pulse forming network alternately to decrease the potential of the guides in each of said pairs upon the occurrence of individual ones of said electrical pulses thereby successively to transfer the glow discharge from one of said cathode circuits to another, said pulse forming network including a first electron discharge device having an anode circuit and a control circuit, a first differentiating circuit coupled to the control circuit of said first electron discharge device for differentiating the waveform of individual ones of said electrical pulses to produce in the anode circuit of said first electron discharge device a first pulse of anode current, a second electron discharge device having an anode circuit and a control circuit, and a second differentiating circuit coupled between the anode circuit of said first electron discharge device and the control circuit of said second electron discharge device, the time constant of said second differentiating circuit having a value not exceeding the time constant of said first differentiating circuit to produce in the anode circuit of said second electron discharge device a second pulse of anode current prior to the cessation of the said first pulse of anode current, and means to impress upon the respective guides in each of said pairs negative voltage pulses derived from the respective anode circuits of said electron discharge devices.

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