

1

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AMPLITUDE COMPARISON CIRCUIT

Elliott A. Henry, Bethel, and Alfred N. Paul, Norwalk, Conn., assignors to Sperry Products, Inc., Danbury, Conn., a corporation of New York

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This invention relates to amplitude comparison circuits of the type in which a diode is employed as the comparison element. The reference voltage is applied to the anode of the diode and the energizing voltage is applied to the cathode. When the energizing voltage in a negative-going direction is equal to or less than the reference voltage, the diode will conduct and a trigger may be energized. The period between the generation of the energizing voltage and the instant when the diode is rendered conductive represents the time delay. Therefore by varying the reference voltage, variations in time delay in generating a trigger may be obtained. Heretofore, for reasons to be described more fully hereinafter, such circuits have not been feasible for time delays in excess of 100 microseconds, and generally were not used where time delays in excess of 35 microseconds were required.

It is one of the principal objects of this invention to provide an amplitude comparison circuit of the type described in which long time delays, up to magnitudes of 30,000 microseconds or more, may be obtained without the undesirable results, such as random oscillations and "jitter," heretofore present in these circuits when employed for time delays in excess of 100 microseconds.

It is a further object of this invention to provide an amplitude comparison circuit of the type described which not only permits time delays much longer than were heretofore possible, but also permits step waves as well as trigger pulses to be generated at the end of the time delay.

Further objects and advantages of this invention will become apparent in the following detailed description thereof.

In the accompanying drawings,

Fig. 1 is a wiring diagram showing one embodiment of this invention.

Figs. 2A and 2B are graphs illustrating the theory of the invention.

Referring to Fig. 1, it will be recognized that the elements of a standard multir circuit are shown. The essence of such circuit comprises a diode 10 upon whose plate 11 there is maintained any desired predetermined reference voltage which may be obtained from a suitable voltage source 12 through a potentiometer 15. The cathode 16 of diode 10 is adapted to have the energizing voltage applied thereto. The plate 11 is connected to the control grid 17 of a pentode 18 by capacitor-resistor coupling 19, 20. Voltage is applied to the plate 21 of the pentode from a suitable source of voltage 22. There is normally zero bias on the control grid 17, and tube 18 is normally conducting. There is a feed-back from cathode 23 of tube 18 to cathode 16 of diode 10 by way of transformer 25 whose primary winding 26 is connected to the cathode 23 and whose secondary winding 27 is connected to the cathode 16. While the cathode 16 is at higher voltage level than plate 11 the diode is not conducting, and the feed-back path through

2

the transformer is not complete. However, when an input voltage, in this case of triangular form, is generated from a suitable source and amplified by tube 30 whose output is applied to the cathode 16, there will be reached a point *a* in the negative-going voltage where the voltage on the cathode 16 is equal to the voltage on plate 11. At this point diode 10 begins to conduct, applying a negative voltage on control grid 17, which reduces the flow of current to cathode 23 and hence to primary coil 26, to induce a current in secondary coil 27 which is so connected as to apply a negative voltage to control grid 17. The regenerative circuit thus rendered effective causes very rapid cut-off of tube 18.

The cut-off of tube 18 is caused by the first half cycle of the oscillation of the secondary coil 27 as shown in Fig. 2A at 32. The connection of this coil is such that the first half cycle generated will be in the negative-going direction. However, because the transformer is necessarily of an oscillatory character the negative half cycle will be followed by a positive half cycle 33 which may be sufficient to render tube 18 again conductive if the energizing voltage has not dropped sufficiently in the meantime so that the composite of the energizing voltage plus the positive voltage generated in the secondary coil 27 is insufficient to render tube 18 effective. For this reason it has been impossible to utilize broad slopes of energizing voltage in order to obtain a long delay time *t* because in succeeding cycles the positive voltages of the transformer coil 27 together with the energizing voltages still present were sufficient to render coil 18 again conductive, and thus set up jitter and oscillations. Hence only steep slopes on the order of 5 volts per microsecond could be employed, and consequently only short delay times *t* could be obtained. In practice these delays seldom exceeded 35 microseconds. Furthermore it was impossible to obtain a step wave at the output of plate 21 since the tube was turned on and off rapidly a plurality of times throughout the slope portion *a—b*.

To obviate the above limitations in the use of the multir circuit for obtaining long time delays and also for obtaining step waves after the time delay, there is provided the arrangement shown in Fig. 1 wherein at point *a* where the diode 10 initially becomes conductive, the voltage is rendered rapidly negative to such degree that subsequent positive cycles of transformer coil 27 are ineffective to render tube 18 again conducting. Thus by reference to Fig. 2B it will be seen that if the voltage applied to cathode 16 during the first half negative cycle of the transformer coil 27 is rendered very substantially negative as shown at 40, then subsequent positive cycles of the coil 27 will raise the voltage to a point such as 41 which is below cut-off for tube 18. For this purpose there is connected to the output of tube 18 at 45 the input grid 46 of a normally non-conducting tube 47, so that when tube 18 is cut off in the initial negative half cycle of coil 27, the voltage rises at plate 21 and this large voltage is applied to grid 46 to render tube 47 conducting. When tube 47 becomes conducting it provides a relatively low impedance path for the energizing voltage applied to cathode 16 because it will draw current from the energizing voltage input at point 48 to lower this voltage rapidly as shown at *a—d* in the graph in Fig. 1. The negative-going voltage shown at 40, Fig. 2B, is of such magnitude 50 that further positive alternations of transformer coil 27 will be insufficient to raise the voltage level above cut-off and therefore will be insufficient to render tube 18 conductive. Tube 18 therefore remains cut off until the next energizing voltage is applied to cathode 16 and raises the voltage sufficiently to render tube 10 non-conducting. This represents the end of the step wave generated at plate 21.

3

A diode 52 is provided to clip off the negative overshoot of coil 26. This overshoot if not clipped would tend to render tube 18 again conductive.

Having described our invention, what we claim and desire to secure by Letters Patent is:

1. In an amplitude comparison circuit comprising a diode having an anode and a cathode, an adjustable source of reference voltage connected to the anode, the cathode being connected to a source of energizing voltage pulse, a normally conducting tube having a control grid coupled to the diode anode and having an anode and a cathode, a regenerative circuit including a transformer having its primary winding connected to the tube cathode and having its secondary winding connected to the diode cathode, said regenerative circuit being ineffective as long as the diode is non-conducting but becoming effective to render said tube non-conducting when the diode becomes conducting, the improvement which comprises means for maintaining said tube non-conducting throughout the duration of said energizing voltage pulse, said last-named means comprising a path of low impedance relative to the impedance of the energizing voltage circuit, the low impedance path including an auxiliary tube having anode, grid and cathode and normally maintained non-conducting to render the low impedance path ineffective, the output of said first tube being connected to the input of said auxiliary tube whereby the positive pulse generated when said first tube is rendered non-conducting is applied to the input of said auxiliary tube to render the auxiliary tube conducting and the low impedance path effective.

2. In an amplitude comparison circuit comprising a diode having an anode and a cathode, an adjustable source of reference voltage connected to the anode, the cathode being connected to a source of energizing voltage pulse, a normally conducting tube having a control

4

grid coupled to the diode anode and having an anode and a cathode, a regenerative circuit including a transformer having its primary winding connected to the tube cathode and having its secondary winding connected to the diode cathode, said regenerative circuit being ineffective as long as the diode is non-conducting but becoming effective to render said tube non-conducting when the diode becomes conducting, the improvement which comprises means for maintaining said tube non-conducting throughout the duration of said energizing voltage pulse, said last-named means comprising a path of low impedance relative to the impedance of the energizing voltage circuit, the low impedance path including an auxiliary tube having anode, grid and cathode and normally maintained non-conducting to render the low impedance path ineffective, the plate of said first tube being connected to the grid of said auxiliary tube whereby the positive pulse generated when said first tube is rendered non-conducting is applied to the grid of said auxiliary tube to render the auxiliary conducting and the low impedance path effective.

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