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TRIGGERING SYSTEM FOR OBTAINING A SHARP-SIDED OUTPUT PULSE SHORTER THAN THE INPUT PULSE

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Fig. 1.

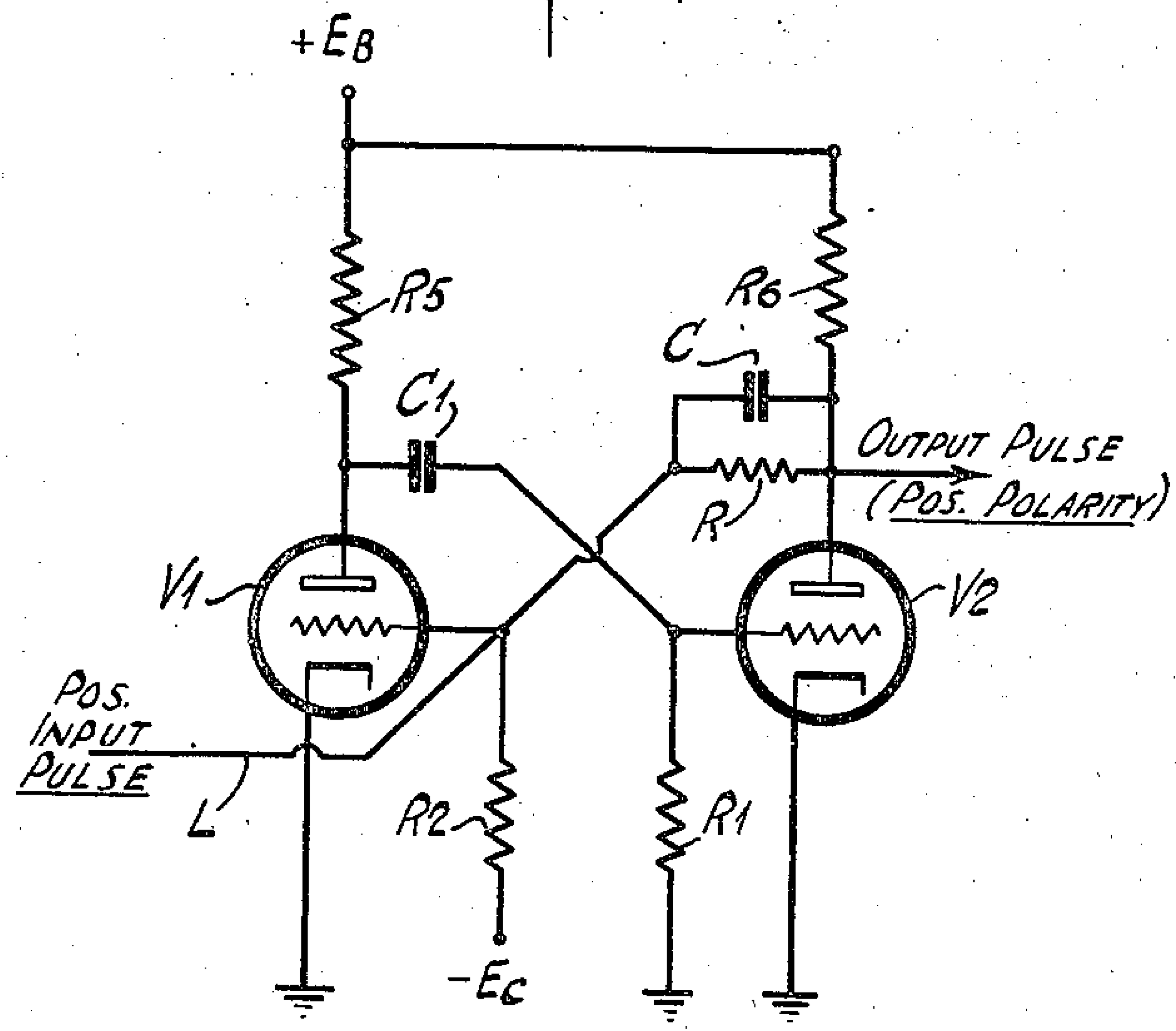


Fig. 2.

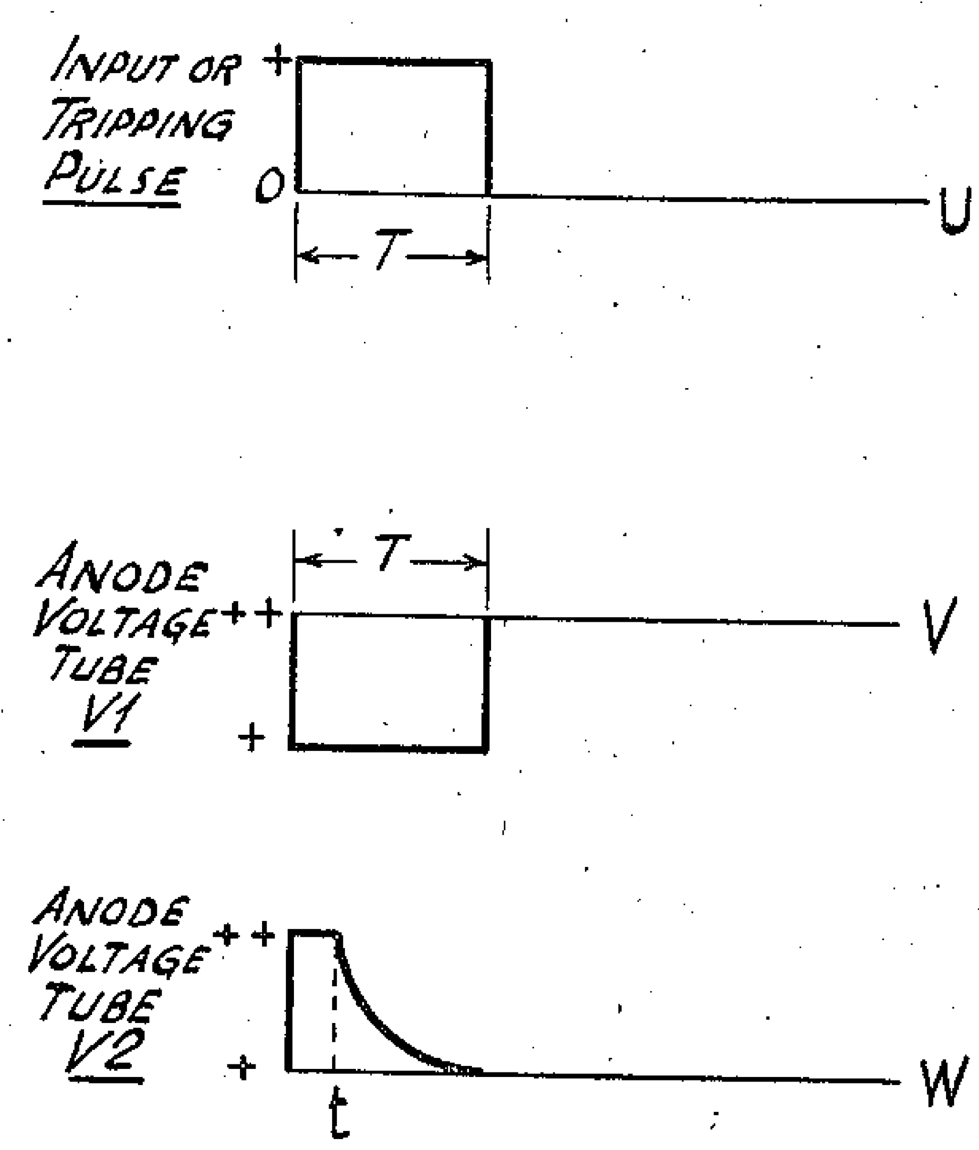
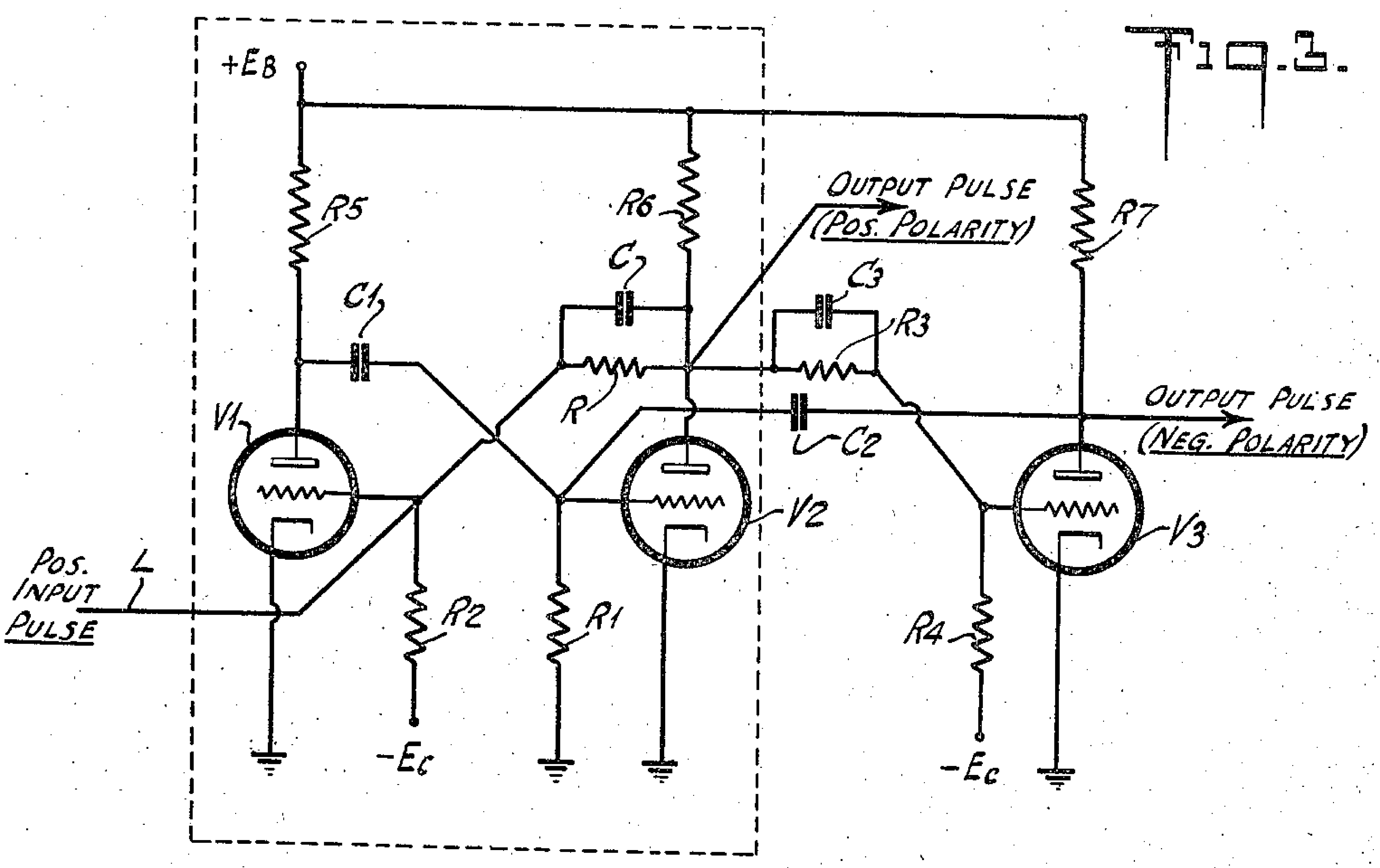


Fig. 3.



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TRIGGERING SYSTEM FOR OBTAINING A SHARP-SIDED OUTPUT PULSE SHORTER THAN THE INPUT PULSE

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9 Claims. (Cl. 250—27)

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This invention relates to high vacuum tube trigger circuits and particularly to a system for obtaining a rectangular or square wave output pulse whose duration is less than that of an input pulse.

It is known to employ vacuum tube trigger circuits for producing rectangular wave pulses. One such trigger circuit utilizes a pair of vacuum tubes coupled regeneratively so that the trigger has one degree of electrical stability. In such a system, one vacuum tube is normally conducting while the other is normally non-conducting. The application of an input or tripping pulse to a suitable electrode of the non-conducting tube and of such polarity and magnitude as to render this normally non-conducting tube conductive, will reverse the current passing conditions of the two tubes of the trigger for a duration depending upon the time constants of the trigger circuit. The output pulse is customarily taken from the anode circuit of either one of the vacuum tubes depending upon the polarity of output pulse desired. Such known type of trigger circuit has been used where it is desired to obtain a rectangular output pulse whose duration is equal to or greater than the duration of the input pulse.

One difficulty with the foregoing known type of trigger circuit is that it is impossible to obtain therefrom a rectangular wave pulse with a steep end slope or trailing edge and whose duration is shorter than the duration of the input pulse. This difficulty is overcome by the present invention which provides a system whereby the output pulse may have any desired duration relative to the input pulse and still be of rectangular shape with steep starting and trailing edges.

A more detailed description follows in conjunction with a drawing, wherein:

Fig. 1 shows a conventional or known type of trigger circuit;

Fig. 2 graphically illustrates the operation of the system of Fig. 1 under one particular condition; and

Fig. 3 illustrates an embodiment of the invention for obtaining a rectangular wave output pulse of shorter duration than the input pulse and with a steep end slope or trailing edge.

Referring to Fig. 1 in more detail, there is shown a known type of trigger circuit comprising a pair of vacuum tubes V1 and V2. The anodes of both vacuum tubes are supplied with a positive polarizing potential from terminal E_B through resistors R5 and R6, respectively. Vacuum tube

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V1 is normally non-conducting by virtue of a negative bias supplied to the grid thereof through resistor R2 by means of source $-E_c$. Vacuum tube V2 is normally conducting and has its grid coupled to the anode of tube V1 through condenser C1. The grid of tube V2 is also connected to ground through resistor R1. The anode of tube V2 is connected to the grid of tube V1 through a condenser-resistor combination C, R. The input or tripping pulse may be applied to the grid of normally nonconductive tube V1 through lead L. The output pulse of positive polarity can be derived from the anode of tube V2. If an output pulse of negative relative polarity is desired, this can be obtained from the anode of tube V1.

In the operation of the conventional trigger circuit of Fig. 1, the application of a positive tripping or input pulse to lead L of sufficient magnitude to cause the tube V1 to conduct will cause the application of a negative pulse to the grid of tube V2 through condenser C1. This negative pulse will reduce the flow of current through tube V2 and, by virtue of the regenerative action of the resistor-condenser combination C, R, the vacuum tube V1 will conduct its maximum current while the vacuum tube V2 (by virtue of the connection through condenser C1) will cease conducting altogether. Vacuum tube V2 will continue in its nonconductive state until such time as the charge on condenser C1 leaks off through resistor R1 or, putting it in other words, the trigger circuit will remain tripped or in its active state for a time depending primarily upon the time constant consisting of condenser C1 and resistor R1. After this time interval in the active state, the trigger circuit will restore itself to its normal or stable state. Such a circuit is known as one which has one degree of stability. In utilizing the circuit of Fig. 1, it has been customary to obtain a rectangular wave output pulse from the anode of tube V1 or V2 whose duration is equal to or greater than the duration of the input or tripping pulse applied to lead L. It has not been possible, however, to obtain from the trigger circuit of Fig. 1 an output pulse of rectangular wave form with a steep trailing slope or edge and which has a duration which is shorter than that of the input pulse. The reason for this will appear from an inspection of Fig. 2.

In Fig. 2, line U shows, by way of example only, an input or tripping pulse which can be applied to the trigger circuit. This pulse has a positive polarity and a duration T. It is desired to obtain from the trigger circuit a pulse of a duration shorter than the input pulse of duration T. Line V shows the voltage pulse which can be obtained from the anode of tube V1. This voltage pulse, it should be noted, varies from a high positive value indicated by the symbols + + to a lower positive value. This pulse will, therefore, be in a negative direction and has a duration equal to T. Line W, however, indicates the shape of the voltage pulse obtainable from the anode of tube V2. This last voltage pulse is in a positive direction and varies from a positive value + to a higher positive value + +. It will be noted that the starting edge or slope of the voltage pulse in line W is steep but that the trailing edge or slope of this pulse decreases exponentially. Line W shows the shape of the pulse obtainable from the trigger circuit of Fig. 1 when it is desired to obtain a pulse whose duration is shorter than that of the input pulse. It should be noted that the pulse of line W is no longer rectangular in form, and that the output pulses obtainable from the anodes of tubes V1 and V2 are no longer identical in wave shape although opposite in polarity. It is assumed, of course, that in attempting to obtain the shorter duration pulse with the circuit of Fig. 1, the values of condenser C1 and resistor R1 were suitably adjusted to provide the desired time constant. The reason for the exponential or drooping trailing edge of the pulse of line W is due to the fact that the input or tripping pulse U holds the tube V1 of the trigger circuit in its conductive state and prevents regeneration action in the trigger circuit during time T, which regeneration action would normally provide instantaneous return of tube V2 to full conductivity at time *t*. It will thus be seen that for a time both tubes V1 and V2 are conductive simultaneously in the condition where it is attempted to obtain from the anode of tube V2 an output pulse of a duration shorter than the input pulse.

The system of Fig. 3 shows an embodiment in accordance with the invention by means of which it is possible to obtain an output pulse of rectangular wave form having steep starting and trailing edges and whose duration is shorter than that of the input pulse. The same reference characters have been used in Fig. 3 to indicate the same parts of Fig. 1. Thus, the conventional trigger circuit of Fig. 1 is illustrated in Fig. 3 as comprising the vacuum tubes V1 and V2 with its associated resistors and condensers. That portion of Fig. 3 which is identical with Fig. 1 is shown in the dotted line box. Fig. 3 provides an additional circuit to that shown in Fig. 1, and this additional circuit comprises a vacuum tube V3 whose grid is coupled to the anode of tube V2 by a parallel resistor-condenser combination R3, C3. The grid of tube V3 is also connected through a resistor R4 to a negative biasing source $-E_c$. The anode of tube V3 is supplied with a positive polarizing potential from source $+E_B$ through resistor R7. The anode of tube V3 is also connected to the grid of tube V2 by means of condenser C2. Tube V3 is normally non-conducting by virtue of the negative bias applied to its grid by source $-E_c$. An inspection of Fig. 3 will thus show that the tubes V2, V3 can be considered as a trigger circuit because these two tubes are connected together in substantially the same manner as tubes V1, V2 are connected together. It should be noted that tubes V1 and V3 are normally non-conducting while tube V2 is normally conducting. An output pulse of positive polarity is obtainable from the anode of tube V2, while an output pulse of negative polarity is obtainable from the anode of tube V3, as shown.

In the operation of the system of Fig. 3, let us assume that a positive input pulse is applied to the grid of tube V1 and that it is desired to obtain from the system of Fig. 3 a rectangular wave output pulse of a duration shorter than that of the applied input pulse. The application of a positive input or tripping pulse to lead L of a magnitude sufficient to reverse the current passing conditions of tubes V1 and V2 considered together as a conventional trigger circuit, will cause a positive pulse to be applied to the grid of tube V3 through the parallel resistor-condenser combination R3, C3. By suitable selection of the values of elements R3, C3 and R4, this positive pulse applied to the grid of V3 will have a magnitude sufficient to overcome the negative bias on the grid of tube V3 and cause the tube V3 to conduct. When tube V3 conducts, it will apply a negative pulse to the grid of tube V2 through condenser C2, and this negative pulse occurs substantially simultaneously for all practical purposes with the application of the negative pulse to the grid of tube V2 from the anode of tube V1. The negative voltage across resistor R1 produced by the combination of voltages from condensers C1 and C2 will start to leak off and increase in a positive direction toward the cut-off value of grid bias of tube V2. When this cut-off value has been just exceeded, the tube V2 will start to conduct. The time at which this occurs is indicated by time *t* of line W of Fig. 2. Thus, when tube V2 starts to conduct, it will by regenerative action with V3 apply a negative pulse to the grid of V3, and tube V3 in turn will have its current flow therein decreased. The decrease of current in tube V3 will result in the application of a positive voltage to the grid of tube V2 and hasten the action of tube V2 in restoring itself to full conductivity. The tubes V2 and V3 thus function in the manner of a trigger circuit having one degree of stability and the regenerative action of this trigger is utilized to restore the normal conduction state of tube V2. It should be noted that tube V2 has thus been restored to full conductivity at time *t* (note line W, Fig. 2) despite the fact that the input pulse applied to lead L still holds tube V1 in a conductive state. An output pulse of positive polarity and of rectangular wave form can be obtained from the anode of tube V2 or one of negative polarity from the anode of tube V3, and this output pulse can have a duration shorter than that of the input or tripping pulse applied to lead L. This output pulse of rectangular wave form has extremely steep starting and trailing edges or slopes. The system of Fig. 3 can be looked at from another standpoint. Tubes V2 and V3 can be considered as a trigger circuit which operates independently of tube V1, although the tube V1 is required to change the trigger circuit V2, V3 from its stable to its active state.

What is claimed is:

1. In combination, a pair of multi-electrode vacuum tube electrode structures having anode and grid electrodes so interconnected regeneratively as to produce a trigger circuit of one degree of electrical stability, whereby said trigger circuit has a stable state in which one structure is normally non-conductive and the other structure normally conductive, and an active state in which these conductive states are reversed, an input circuit connected to an electrode of one of said structures for supplying

thereto a pulse of such polarity and magnitude as to trip said trigger circuit and thereby reverse the normal conditions of conductivity of the structures, and circuit elements including another multi-electrode structure having its electrodes regeneratively coupled to the electrodes of said normally conductive structure for causing said normally conductive structure to restore itself to the conductive state prior to the termination of the tripping pulse and without the use of a restoring pulse.

2. In combination, a pair of multi-electrode vacuum tube electrode structures having their anode and grid electrodes so interconnected regeneratively as to produce a trigger circuit of one degree of electrical stability, whereby said trigger circuit has a stable state in which one structure is normally non-conductive and the other structure normally conductive, and an active state in which these conductive states are reversed, an input circuit connected to an electrode of one of said structures for supplying thereto a pulse of such polarity and magnitude as to trip said trigger circuit and thereby reverse the conditions of normal conductivity of the structures, and another multi-electrode vacuum tube electrode structure having anode and grid electrodes, and impedance elements between said last electrodes and the anode and grid electrodes of said normally conductive electrode structure so as to cause said normally conductive electrode structure to restore itself to its conductive state independently of the length of the tripping pulse.

3. In combination, a trigger circuit having only one degree of electrical stability and comprising first and second electron discharge devices whose anode and grid electrodes are interconnected regeneratively, said first device being normally non-conductive and said second device normally conductive when said trigger circuit is in its stable state, and a third electron discharge device having anode and grid electrodes interconnected regeneratively with the anode and grid electrodes of said second device so as to provide therewith a trigger circuit having one degree of electrical stability, said third device being normally non-conductive, and an input circuit for supplying a tripping pulse to said first trigger circuit.

4. In combination, first, second and third vacuum tubes, each having grid, anode and cathode electrodes, impedances interconnecting the anode and grid electrodes of said first and second tubes, and means for supplying polarizing and biasing potentials to the electrodes of said first and second tubes of such values as to produce a trigger circuit having one degree of electrical stability, impedances interconnecting the anode and grid electrodes of said second and third tubes, and means for supplying polarizing and biasing potentials to said third tube of such values as to produce from said interconnected second and third tubes a trigger circuit having one degree of electrical stability.

5. In combination, a trigger circuit having one degree of electrical stability comprising a pair of interconnected vacuum tubes, and a second trigger circuit having one degree of electrical stability, said second trigger circuit comprising one tube of said first trigger circuit and an additional vacuum tube, said tubes of said second trigger circuit having their electrodes interconnected regeneratively, an input circuit for supplying a tripping pulse to said first trigger circuit, and an output circuit for deriving rectangular wave pulses connected to one of the tubes of said second trigger circuit.

6. In combination, first and second vacuum tubes interconnected to provide a trigger circuit having one degree of electrical stability, a condenser connecting the anode of said first tube to the grid of said second tube, a condenser shunted by a resistor connecting the anode of said second tube to the grid of said first tube, a source of negative biasing potential connected to the grid of said first tube through a resistor, a connection including a resistor between the grid and cathode of said second tube, whereby said first tube is normally non-conductive and said second tube normally conductive when said trigger circuit is in its stable state, and a third vacuum tube having its anode and grid electrodes connected to said second tube in a manner similar to the way in which said first tube is connected to said second tube, and a source of negative biasing potential connected to the grid of said third tube through a resistor, whereby said second and third tubes form a trigger circuit having one degree of electrical stability in which said second tube is normally conductive and said third tube normally non-conductive, an input circuit connected to the grid of said first tube for supplying a tripping pulse of positive polarity thereto, and an output circuit connected to the anode of one of said tubes of said second trigger circuit for deriving rectangular wave pulses therefrom of a length shorter than the tripping pulse.

7. In combination, first and second vacuum tube electrode structures interconnected to provide a trigger circuit having one degree of electrical stability, a condenser connecting the anode of said first structure to the grid of said second structure, a condenser shunted by a resistor connecting the anode of said second structure to the grid of said first structure, a source of negative biasing potential connected to the grid of said first structure through a resistor, a connection including a resistor between the grid and cathode of said second structure, whereby said first structure is normally non-conductive and said second structure normally conductive when said trigger circuit is in its stable state, and a third vacuum tube electrode structure having its anode and grid electrodes connected to said second structure in a manner similar to the way in which said first structure is connected to said second structure, and a source of negative biasing potential connected to the grid of said third structure through a resistor, whereby said second and third structures form a second trigger circuit having one degree of electrical stability in which said second structure is normally conductive and said third structure normally non-conductive, an input circuit connected to an electrode of said first structure for supplying a tripping pulse thereto, and an output circuit connected to the anode of one of said structures of said second trigger circuit for deriving rectangular wave pulses therefrom of a length shorter than the tripping pulse.

8. In combination, a pair of multi-electrode vacuum tube electrode structures having their anode and grid electrodes so interconnected regeneratively as to produce a trigger circuit of one degree of electrical stability, whereby said trigger circuit has a stable state in which one structure is normally non-conductive and the other structure conductive, and an active state in which these conductive states are reversed, an

input circuit connected to an electrode of one of said structures for supplying thereto a pulse of such polarity and magnitude as to trip said trigger circuit and thereby reverse the normal conditions of conductivity of the structures, said tripping pulse having a time duration which is longer than that of a desired output pulse, another multi-electrode structure, and impedance elements connecting certain electrodes of said last structure with the anode and grid electrodes of said normally conductive structure regeneratively for causing said normally conductive structure to restore itself to the conductive state prior to the termination of the tripping pulse and without the use of a restoring pulse.

9. In combination, a trigger circuit comprising first and second electron discharge device electrode structures each having anode and grid electrodes, impedance elements interconnecting the anode of each of said structures with the grid of the other structure, such that said trigger circuit has only one degree of electrical stability, and a third electron discharge device electrode structure having anode and grid electrodes, and impedance elements interconnecting the anode and grid electrodes of said third structure with the grid and anode electrodes of said second structure in such manner that said second and

third structures also form a trigger circuit having only one degree of electrical stability.

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