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2,588,925

ELECTRONIC TRIGGER CIRCUIT

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FIG. 1.

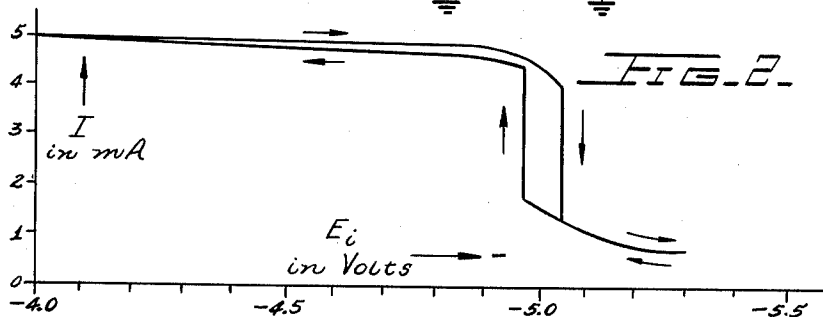
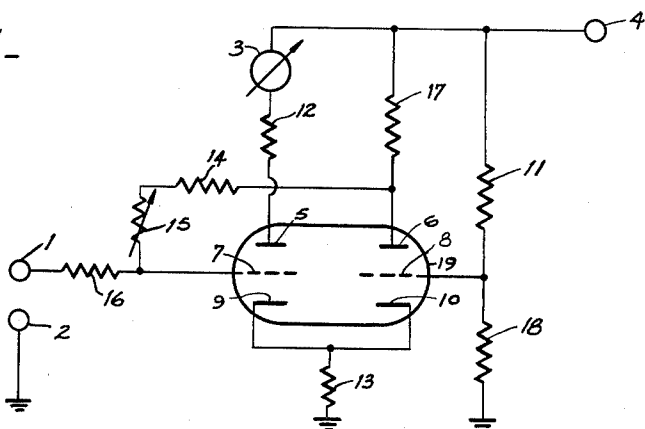


FIG. 2.

FIG. 3.

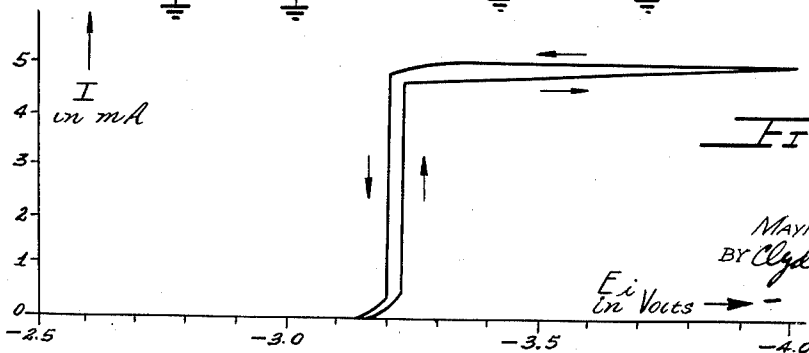
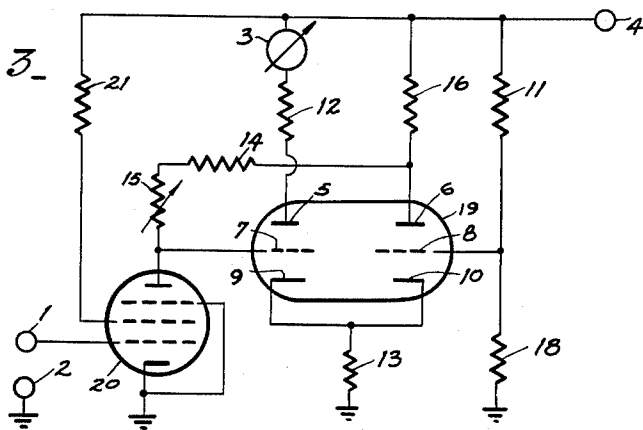


FIG. 4.

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ELECTRONIC TRIGGER CIRCUIT

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5 Claims. (Cl. 250-27)

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This invention relates to an improved electronic D. C. feed back trigger circuit employing a two-stage amplifier and improved circuits which cooperate to provide a highly sensitive and efficient triggering action while operating with a small maximum backlash voltage.

It is an object of this invention to provide an improved and novel thermionic trigger circuit.

It is a further object of this invention to provide an improved trigger circuit which appreciably reduces back-lash voltage.

It is a further object of this invention to provide an improved thermionic trigger circuit with greater sensitivity and efficiency.

These objects and others auxiliary thereto are obtained by providing a two stage trigger circuit with a common cathode resistance and feeding back a positive voltage from the plate of the second stage to the control grid of the first or input stage.

The novel features of the invention are set forth with particularity in the appended claims. The invention, itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawings in which:

Figure 1 is a schematic circuit diagram of the trigger circuit.

Figure 2 is a graph in which the measured output current is plotted against the input voltage for the circuit as shown in Figure 1.

Figure 3 is a schematic circuit diagram showing a modification of the circuit shown in Figure 1.

Figure 4 is a graph in which the measured output current is plotted against the input voltage for the circuit shown in Figure 3.

Heretofore the known D. C. feed-back amplifier trigger circuits have left much to be desired as regards backlash and consequent efficiency and sensitivity. In the preferred embodiment of the instant invention, these factors are considerably improved.

The term back-lash as used herein means the difference in the values of the input voltage where the output current rises abruptly while said input voltage varies in one direction and where it drops while said input voltage varies in the opposite direction, as indicated on the graphs shown in Figures 2 and 4.

Referring to Figure 1 of the drawings, tube 19 is a twin triode, for example, a type 6SN7 tube.

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The twin triode is illustrated for the sake of simplicity, it being understood that two triodes or two tubes having multiple grids may be used in place thereof. The negative input D. C. control voltage is applied between terminals 1 and 2 to the grid 7 and cathode 9 of the first stage of tube 19, said first stage including cathode 9 and anode 5. Cathode 9 of the first stage is coupled to cathode 10 of the second stage by a resistance coupling including common resistance 13. As the said input at terminal 1 becomes more negative the current flow in the first stage, from cathode 9 to anode 5, will decrease gradually until a predetermined value of input voltage is reached, at which point the current output of the first stage, as measured by meter 3, will drop rapidly for only a minute further increase of the negative input voltage (in a negative direction). At this point, shown by the vertical line at the right of Fig. 2, the trigger action occurs, and the circuit flips over from one stable set of operating conditions to the other, characteristic of trigger circuits. Continued increase of negative control voltage will cause the circuit to follow to the right on the curve at the lower end of the vertical line to the right of Fig. 2.

If now, the control voltage be given small increments in the positive direction, the current will gradually increase until suddenly it will jump, as shown by the vertical line to the left of Fig. 2, and still further increments of input voltage in a positive direction will cause only a slow further increase in plate current, as shown by the lower line of the top section of Fig. 2.

Just how this action takes place with my circuit will now be explained. Assuming that the input voltage is changed from -4 volts to -4.75 volts, the plate current to anode 5 will decrease. This decrease in plate current decreases the IR drop through common cathode resistor 13, increasing, in a positive sense, the voltage between grid 8 and cathode 10, causing an increase in plate current to anode 6. This causes the potential of anode 6 to move in a negative direction, and this change of potential is fed back, through resistances 14 and 15 to grid 7, still further reducing the plate current to anode 5. The action is cumulative, and as the negative input potential reaches the trigger value, 5.05 volts in Fig. 2, the trigger action occurs.

In a similar manner, the reverse action occurs when the input voltage is changed in a positive direction.

The circuit differs from the well known Schmitt trigger circuit (see O. H. Schmitt, "A Thermionic

Trigger," Jour. Sci. Insts., 1938, XV, pp. 24-26) both in construction, and in greatly improved performance, as will be explained.

The Schmitt circuit is a two stage D. C. amplifier with positive feedback. Trigger action takes place when the positive feedback is of such a magnitude that the circuit would not be stable for a given state of current flow in the two stages. If the said Schmitt circuit contained, in the proper connection, a component capable of storing energy, as for instance a capacitive or an inductance or both, then the above condition could lead to continuous oscillation. Without such an energy storing reservoir, the above circuit can do nothing but slip to a stable state of D. C. current flow whenever the previous state is adjusted beyond the limit of stability. An equivalent condition would exist in a D. C. amplifier which works on the negative resistance characteristic of certain multigrid tubes, since negative resistance and positive feedback have an equivalent influence on the stability of an amplifier.

The brief discussion above is intended to show that positive feedback or a negative resistance characteristic are general ways of producing a trigger action. The Schmitt circuit specifies one particular way of producing said positive feedback, namely, by means of a common cathode resistor between two D. C. coupled amplifier stages. The coupling from the first to the second stage is accomplished in the Schmitt circuit by means of a resistor between the plate of the first and the grid of the second stage.

The instant invention has no interstage coupling resistor between the plate of the input stage and the grid of the second stage. Instead there is a feedback coupling resistance 14+15 between the plate of the second stage and the control grid of the input stage. This resistance 14+15 provides a positive voltage feedback whereas the Schmitt circuit works by positive current feedback because of the common cathode resistor. Figure 1 also shows a common cathode resistor 13 but in this circuit, resistor 13 serves only to couple the input stage to the second stage because there is no other provision in the circuit to provide for coupling from the first to the second stage.

The trigger circuit of this invention operates as follows:

(1) Current coupled from input to second stage by means of a common cathode resistor.

(2) Positive voltage feedback by means of a resistor between the plate of the second stage and the grid of the input stage.

The Schmitt circuit, on the other hand, works as follows:

(1) Voltage coupled from the plate of the input stage to the grid of the second stage by means of a resistor.

(2) Positive current feedback by means of a common cathode resistor.

Resistors 14+15 and 16 plus the internal output resistance of the input voltage source and the amplification of the second stage determine the feedback voltage ratio.

The same resistors, together with resistor 13, determine simultaneously the correct bias for the control grid of the first stage, whereas resistors 11 and 18 together with resistor 13 determine only the correct bias for the control grid of the second stage. In order to have the grids at the correct working point, the cathode resistor must be considerably larger than is recommended for the Schmitt circuit. The two stages are, therefore, virtually self-biasing, but the backlash volt-

age can be kept at a tolerably small value in spite of the high value of resistance 13 (20,000 ohms for instance), whereas the Schmitt circuit has a high backlash voltage for such a large cathode resistor. The reason for this is that the feedback voltage in my circuit can be adjusted independently of the voltage drop across the common cathode resistor, by choosing the proper values for resistors 14, 15 and 16. This provides a feedback sufficient to overcome a state of equilibrium with a lower backlash voltage than is possible with the Schmitt circuit, while keeping the feedback low enough to avoid holding the circuit too tightly in one state of equilibrium. Too tight maintenance of equilibrium could occur, if, for instance, so much feedback were used so as to drive the input grid so far positive that the heavy plate current in the first stage would give too large a voltage drop in the common cathode resistor. Figure 2 shows the trigger curve measured for the circuit shown in Figure 1.

The curve in Figure 2 was plotted for the following circuit values:

- Resistance 16=0.4 megohm
- Resistance 14=0.3 megohm
- Resistance 12=10,000 ohms
- Resistance 17=3,000 ohms
- Resistance 13=20,000 ohms
- Resistance 11=0.3 megohm
- Resistance 18=0.3 megohm
- Resistance 15=70,000 ohms full value, (adjusted to 41,500 ohms)
- Plate potential at 4=205 volts
- Tube 19 is type 6SN7
- Input voltage across 1,2=approx. 5 volt at triggering point

The backlash voltage was, in this case, approximately 0.07 volt.

Figure 3 shows a further development of the circuit shown in Figure 1. The resistor 16 of Figure 1 has been replaced in Figure 3 by the internal plate resistance of the pentode 20. The feedback resistor 14+15 now serves (together with resistor 17) as plate load resistor for tube 20. That means that tube 20 can now be used as a pre-amplifier, with the signal voltage fed into its control grid. This way a considerable decrease in the magnitude of the backlash voltage can be achieved while keeping the current drain of the source of plate supply voltage practically as low as without tube 20. Figure 4 shows the measured trigger curve for the circuit values given in Figure 3 when:

- Tube 19 is type 6SN7
- Tube 20 is type 6SJ7
- Resistance 15=70,000 ohms (full value)
- Resistance 14=0.3 megohm
- Resistance 12=10,000 ohms
- Resistance 16=1,600 ohms
- Resistance 11=0.3 megohm
- Resistance 18=0.3 megohm
- Resistance 13=20,000 ohms
- Resistance 21=2.0 megohms
- Plate potential at 4=205 volts
- Input voltage across 1, 2=approx. 3.2 volts for triggering action

In this case, the backlash voltage was around 0.02 volt. Since the pre-amplifier tube 20 is an integral part of the trigger circuit, any minor drifts previously observable on the grid of the input tube of Figure 1 are considerably reduced at the input of tube 20 because of the amplification between plate and control grid of tube 20.

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Thus the circuit in Figure 3 supplies not only a smaller backlash voltage but also smaller error sources due to drift than the circuit of Figure 1.

The circuit of Figure 3 can provide a smaller backlash voltage not only because of the amplification in tube 20 but also because this tube represents a variable resistance as part of the positive feedback network. The higher said positive feedback is, the larger is the backlash. Now, if the negative voltage input increases, the resistance of tube 20 increases and, consequently, the positive feedback increases. If the negative voltage input decreases, then the resistance of tube 20 decreases and the positive feedback decreases. Since in this circuit the input voltage at which the output current, measured at meter 3, starts to flow, is much less dependent on the amount of positive feedback than that input voltage at which the current stops flowing, which latter occurrence takes place with decreasing negative value of the input voltage, it is clear that this effect makes an additional contribution to minimizing the backlash voltage.

In the specification, I have explained the principles of my invention and the best mode in which I have contemplated applying those principles, so as to distinguish my invention from other inventions; and I have particularly pointed out and distinctly claimed the part, improvement or combination which I claim as my invention or discovery.

While I have shown and described certain preferred embodiments of my invention, it will be understood that modifications and changes may be made without departing from the spirit and scope thereof, as will be clear to those skilled in the art.

I claim:

1. An electronic trigger circuit comprising a first stage having an input grid, a cathode and an anode, a second stage having a grid, a cathode and an anode, a common cathode resistor coupling the cathodes of the two stages and forming the sole coupling between the output of the first stage and the input of the second stage, resistance means connected to the grid and cathode of the second stage for determining the

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bias potential of said grid, and a positive feedback voltage line connecting the anode of the second stage to the input grid of the first stage.

2. An electronic trigger circuit comprising a first stage having an input grid, a cathode and an anode, a second stage having an input grid, a cathode and an anode, a common cathode resistor coupling the cathodes of the two stages, and forming the sole means coupling the output of the first stage to the input of the second stage, resistance means connected to the grid and cathode of the second stage for determining the bias potential of said grid, and resistance means connecting the anode of the second stage to the input grid of the first stage.

3. The circuit claimed in claim 2, in which the said resistance means connecting the anode of the second stage to the input of the first stage includes the space current path of a multiple grid vacuum tube.

4. The combination claimed in claim 2 in which the said resistance means connecting the anode of the second stage to the input of the first stage includes the space current path of an electron tube having a cathode, an anode, and a control electrode.

5. An electronic trigger circuit characterized by small backlash voltage and consequent great sensitivity, comprising an input stage with an electronic tube, having cathode, anode, and a control electrode, and an output stage with an electronic tube having a cathode, an anode, and a control electrode, current actuated means coupling the output of the input stage to the input of the output stage, and voltage actuated means coupling the output of said output stage to the input of the input stage.

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REFERENCES CITED

The following references are of record in the file of this patent:

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