

July 22, 1952

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ELECTRICAL TRIGGER CIRCUITS

2,604,589

Filed May 15, 1950

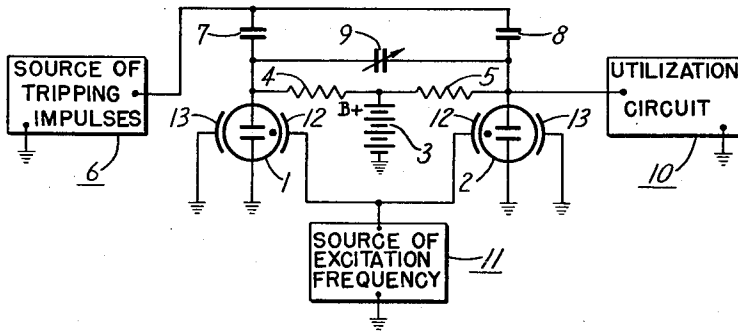


FIG. 1.

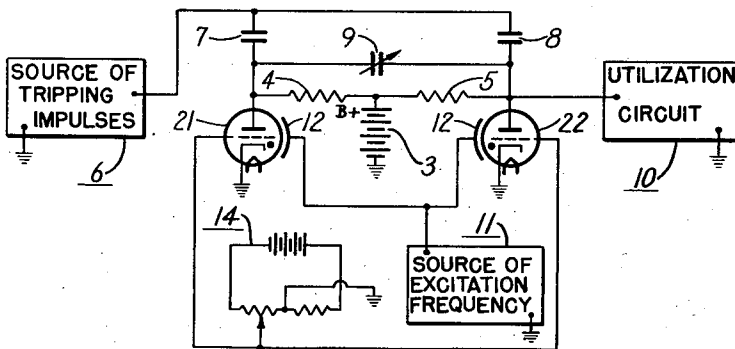


FIG. 2.

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2,604,589

ELECTRICAL TRIGGER CIRCUITS

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Application May 15, 1950, Serial No. 162,127

6 Claims. (Cl. 250—27)

1

This invention relates to trigger circuits and other similar circuits, and also concerns the utilization, in such circuits, of gas tubes whose characteristics are stabilized by external means.

The use in such circuits of small, inexpensive gas tubes, such as the simple neon diode glow tube, has heretofore been inhibited by the inherent lack of stable and uniform characteristics of such tubes.

It is therefore a principal object of the present invention to stabilize the characteristics of gas tubes by an externally applied excitation field.

Another object of the invention is to increase the uniformity in characteristics between any number of similar gas tubes by such excitation field.

Another, and more specific object of the invention is to increase stability and/or uniformity in the characteristics of gas tubes by excitation of such tubes with an externally applied audio or higher frequency field.

A further object of the invention is to reduce the size and/or cost of trigger circuits, or other similar circuits, by utilizing such uniformly stabilized gas tubes in such circuits.

Another object of the invention is to fire and extinguish the gas tubes of trigger circuits and the like by means of only the two principal electrodes of such tubes.

The present invention is therefore based upon the principle of applying an external excitation field to each of one or more gas tubes in a circuit to increase stability of the characteristics of each tube and uniformity of operation of a plurality of such tubes. While gas diodes and triodes are disclosed herein to illustrate the present invention, the application of the above principle to other types of gas-filled tubes also increases their stability and uniformity in the same manner.

Other objects and applications of the invention will appear from the following description, with reference to the drawing in which:

Fig. 1 is a schematic circuit diagram of a preferred embodiment of a trigger circuit, employing two gas diodes.

Fig. 2 is a schematic circuit diagram of a modified embodiment of a trigger circuit, employing two gas triodes.

It has heretofore been necessary, in trigger circuits and other circuits of a similar nature, to use tubes of inherently stable characteristics in order to achieve reliable operation. By application of the principles of the present invention, less stable tubes which are smaller and less expensive than those customarily used, may be

2

employed in such circuits. This makes possible a reduction in the size and cost of the circuit both through simplification of the circuit and through reduction in size and cost of the tubes.

Referring to Fig. 1, a pair of similar gas diodes 1 and 2 are connected in parallel between ground and the positive terminal of a source 3 of unidirectional potential, shown as a battery. The negative terminal of source 3 is grounded. A resistor 4 is connected in series in the discharge circuit of tube 1; likewise, a resistor 5 is connected in series in the discharge circuit of tube 2. Resistors 4 and 5 are of substantially equal value, making the discharge circuits of tubes 1 and 2 symmetrical. The respective values of the B+ voltage of source 3 and the breakdown potentials of tubes 1 and 2 are such that neither tube will be discharged solely by the B+ potential impressed thereon. A source 6 of positive tripping or firing pulses is connected in parallel to the high potential side of each tube 1 and 2 through a respective input condenser 7 and 8 of substantially equal capacitance. A coupling condenser 9 connects the high potential sides of the two tubes. The high potential electrodes of tubes 1 and 2 will hereinafter be designated as the "plates" of the respective tubes.

Operation as a trigger circuit

In the normal condition of rest, neither of the tubes 1 and 2 is in a firing condition, and when operation of the circuit is to be initiated from this condition, a positive firing impulse from source 6, of sufficient magnitude when added to B+ voltage to fire either tube, is impressed simultaneously upon both tubes. Due to the inherent differences between any two such tubes, their breakdown potentials will be at slightly different levels. Therefore, the tube with the lower breakdown potential will discharge before breakdown potential is reached by the other tube. For purposes of illustration, it will be assumed that tube 1 has the lower breakdown potential and is discharged first.

Although the tripping pulse is fed to both tubes simultaneously, the circuit is so arranged that the tube which fires first produces a negative impulse which is fed to the other tube, preventing that other tube from firing.

When tube 1 fires, the positive firing pulse fed from source 6 is discharged through that tube to ground. The discharge current through tube 1 and resistor 4 causes a potential drop across that resistor, lowering the plate potential of tube 1 to its operating level. The operating level is

below $B+$ level by the amount of drop across resistor 4, and it is slightly above the tube's extinction or ionization level.

The plate potential drop of tube 1, caused by the firing of that tube, is fed through the coupling condenser 9 to tube 2, lowering the plate potential of tube 2 and preventing that tube from being fired by the tripping pulse. Thus, the firing impulse causes the plate potential of tube 2 to first surge upward almost to its breakdown level; second, the negative surge from the plate of tube 1 prevents tube 2 from reaching breakdown, and causes its plate potential to drop below $B+$ level to the operating level of tube 1; third, source 3 returns the plate potential of tube 2 to $B+$ level through resistor 5. It is obvious that tube 2 does not fire during this first phase of operation.

After the first tube fires (tube 1 in the present example), a stable condition is reached in which tube 1 is maintained at its operating level and tube 2 at the somewhat higher $B+$ level. This stable condition will prevail until tubes 1 and 2 receive the next tripping pulse from source 3.

Since tube 1 is already firing when it receives the second tripping impulse, its plate potential will not drop at that time, as it did after being fired by the first tripping impulse. Therefore, when such impulse is impressed upon tube 2, that tube is raised above its breakdown potential and fired, since no negative surge from tube 1 across condenser 9 will interfere. As tube 2 fires the firing pulse from source 6 is discharged through that tube to ground. The discharge current through tube 2 and resistor 5 causes a potential drop across that resistor and a consequent drop of the plate potential of tube 2. This drop is fed through the coupling condenser 9 to the plate of tube 1, extinguishing that tube in the following manner.

It will be remembered that, prior to the receipt of the second firing pulse, the plate of tube 1 was at operating potential and tube 2 at $B+$ potential. Since the second firing pulse raises both tube plate levels by the same amount, tube 1, at the peak of that pulse, will still be at a lower level than tube 2. When tube 2 fires and its plate drops to operating level, the plate potential of tube 1 drops by the same amount because of the negative surge from tube 2 to tube 1 across condenser 9. Tube 1, in dropping the same amount as tube 2, falls to a lower value than does tube 2, because tube 1 started dropping from a lower level. Therefore, since tube 2 drops to its operating level, tube 1 drops somewhat below that level. The circuit values are so arranged that tube 1 drops to or below its ionization level and is extinguished, thereafter being raised to $B+$ by source 3.

Receipt of each subsequent successive tripping impulse from source 6 causes conduction to shift from one tube to the other in the manner described above.

Tube stabilization

Small inexpensive gas-filled tubes may be employed in the above-described trigger circuit, providing the operational characteristics of these tubes are stabilized in some manner. It has been found that such stabilization may be accomplished by an external means for causing excitation of the gas in such tubes with an audio or higher frequency field. The resulting stabilization is thought to be due to the establishing of

an artificial degree of ionization of the gas in a tube which tends to eliminate differences in characteristics, both as between any two similar tubes and as over a period of time in a single tube.

In Fig. 1, such stabilizing field is shown as being supplied by a source 11 of the excitation frequency. A receptive external electrode 12, associated with each tube, is connected to the output side of source 11. A second respective external electrode 13, associated with each tube, is grounded, completing the excitation field circuit. Grounded electrodes 13 may be entirely eliminated, the grounding of the internal electrodes and the external circuitry being used to complete the excitation circuit. Furthermore, a single electrode 12 may be employed for establishing the stabilizing field for a plurality of properly grouped tubes.

Fig. 2 illustrates a modified embodiment of the above-described trigger circuit. Those elements in Figs. 1 and 2 which are identified by the same reference numerals are identical both structurally and operatively. The circuit in Fig. 2 employs two gas triodes 21 and 22 in place of the diodes 1 and 2 shown in Fig. 1. The grids of gas tubes 21 and 22 in Fig. 2 are connected to a source 14 of variable D. C. voltage. By varying the value of source 14, the breakdown potential of tubes 21 and 22 may be regulated with negligible effect upon their extinction level, a fact well known in the art. Therefore, varying the value of source 14 will vary the range, in each tube, between its breakdown and extinction levels, allowing regulation of that range for optimum operating conditions. In the description of Fig. 1, it was noted that the grounded external excitation electrodes 13 could be omitted without impairing circuit operation. Such an arrangement is illustrated in Fig. 2.

It will be apparent that either trigger circuit described above may be used in an ordinary binary counting circuit by connecting an appropriate number of such trigger circuits in series and feeding to each trigger circuit, tripping pulses which are tapped from the high potential electrode of either tube in the preceding circuit. By observing which tube in each circuit is conducting, it may be readily ascertained how many tripping pulses have been introduced into the system.

It will also be noted that the formed pulses appearing at either tube plate may be coupled, in a suitable manner, into any desired utilization circuit 10 (Figs. 1 and 2), as well as into succeeding trigger circuit stages. Furthermore, it will be obvious to one skilled in the art that the output pulses may be isolated from the input pulses by tapping the former from across a suitable cathode resistor associated with either tube.

It will appear further, that either of the foregoing circuits may be triggered by negative as well as positive tripping pulses. Upon receipt of a negative pulse, the plate potentials of both tubes drop an equal amount and the conducting tube is extinguished, its potential level rising to $B+$ due to the decreased drop across its plate resistor 4 or 5. That rise in potential is fed to the other tube through coupling resistor 9, raising it above its breakdown level and firing it. The circuit values are such that the rise of the non-conducting tube to breakdown level is smaller than the rise of the conducting tube to $B+$ when it is extinguished. Thus, the rise of the extinguished tube is of sufficient magnitude to raise

5

the other tube above its breakdown level and fire it.

Operation as an oscillator

By raising the B+ voltage to a level slightly above breakdown potential of the two tubes, the circuit shown in either Fig. 1 or Fig. 2 may be made to act as an oscillator in the following manner.

Upon raising the B+ potential of source 3 (Fig. 1) above breakdown potential for this purpose, the tube, 1 or 2, having the lower breakdown potential will fire first. Again, for purposes of illustration, it may be assumed that tube 1 has the lower breakdown potential. When tube 1 fires, its plate potential drops and a negative pulse is fed through coupling condenser 9 and impressed upon tube 2, preventing tube 2 from firing under the influence of the B+ voltage. At the time of the negative surge across condenser 9, both sides of that condenser are lowered to the operating potential of tube 1. The left side (in the drawing) of that condenser remains at such operating level as long as tube 1 continues to conduct. However, the right side of condenser 9, connected to and therefore at the potential of tube 2, is recharged toward B+ level through resistor 5 in an amount of time determined by the time constant of the circuit comprising resistor 5 and condenser 9.

Since B+ is, in an oscillator, at a higher potential than the breakdown level for either tube 1 or 2, tube 2 fires before it has returned to B+ level. Thereupon, the potential drop across resistor 5 causes the plate potential of tube 2 to drop, coupling a negative pulse through condenser 9 to tube 1 and extinguishing that tube in the manner previously described. Each tube in turn will continue to fire in this manner. The circuit will thereby function as a free running oscillator.

It will be remembered that the recovery time for either tube, i. e., the time required for a tube to rise from the level at which it was extinguished to its breakdown level, is determined by the time constant of the circuit consisting of the respective associated resistor 4 or 5 and the coupling condenser 9. Therefore, the recovery time, and consequently the frequency of oscillation, may be varied by varying the value of condenser 9.

Operation as a univibrator

As a further example of the general utility of the circuits illustrated in Figs. 1 and 2, either of these circuits may be used as a one-shot multivibrator or "univibrator."

For this purpose, the tapped positive potential from source 3 to one tube of a circuit must be greater than the breakdown potential of that tube. On the other hand, the potential tapped from source 3 to the other tube of the circuit must be between breakdown level and extinction level for that tube. Therefore, the first of such tubes is normally conducting and the second is normally non-conducting. A positive tripping pulse from source 6 fires the non-conducting tube and extinguishes its companion in the manner described under trigger circuit operation. Recharging of the coupling condenser 9 through the associated discharge circuit resistor 4 or 5 restores the normally conducting tube to conduction. The consequent negative surge across condenser 9 thereupon extinguishes the normally non-conducting tube. It will be apparent that the width of the output pulse, fed to the utiliza-

6

tion circuit 10, may be varied by varying the time constant of the circuit comprising the resistor 4 or 5 associated with the non-conducting tube and condenser 9.

Univibrator action with negative tripping pulses includes the previously described extinction of the normally conducting tube, the consequent firing of the other tube, and the subsequent restoration of the circuit to its rest condition.

I claim:

1. A stabilized pulse generating trigger circuit comprising a pair of gas-filled tubes, each tube having two internal electrodes, a respective connection from one electrode of each of said tubes to ground, a respective discharge resistor connecting the ungrounded electrode of each of said tubes to the positive terminal of a source of unidirectional potential, the potential of said terminal being less than the breakdown potential and greater than the ionization potential of either of said tubes, whereby said trigger circuit is maintained in a fixed condition of operation when either of said tubes is conducting and its companion tube is non-conducting, means for firing said non-conducting tube, means responsive to said firing of the last mentioned tube for extinguishing the other tube, excitation means including, at least one electrode external of and adjacent to said tubes, and a source of audio or higher frequency potential coupled to the external electrode for applying to the gas within said tubes an excitation field of a potential level sufficient to stabilize the characteristics of the tubes but insufficient to sustain conduction between said internal electrodes.

2. A stabilized pulse generating trigger circuit comprising a pair of gas-filled tubes, each having at least a cathode, an anode, and a grid, means for biasing the grid of each of said tubes to establish a predetermined breakdown potential for that tube, a respective connection from the cathode of each of said tubes to ground, a respective discharge resistor connecting the anode of each of said tubes to the positive terminal of a source of unidirectional potential, the potential of said terminal being less than the breakdown potential and greater than the ionization potential of either tube, whereby said trigger circuit is maintained in a fixed condition of operation when either of said tubes is conducting and its companion tube is non-conducting, means for firing said non-conducting tube, means responsive to said firing of the last mentioned tube for extinguishing the other tube, excitation means including, at least one electrode external of and adjacent to said tubes, and a source of audio or higher frequency potential coupled to the external electrode for applying to the gas within said tubes an excitation field of a potential level sufficient to stabilize the characteristics of the tubes but insufficient to sustain conduction between the cathode and anode of either tube.

3. A stabilized pulse generator circuit comprising a pair of gas-filled tubes, each having two internal electrodes, a respective connection from one electrode of each of said tubes to ground, a resistor connecting the remaining electrode of a first one of said tubes to the positive terminal of a source of unidirectional potential, the potential of said terminal being greater than the breakdown potentials of said tubes, whereby said first tube is caused to conduct, and means including a resistor connecting the ungrounded electrode of the second tube to the positive termi-

nal of said source for causing the second tube to conduct to thereby produce a negative surge at the ungrounded electrode of the second tube, a condenser mutually connecting the respective ungrounded electrodes of the first and second tubes to couple said negative surge to said ungrounded electrode of the first tube for extinguishing said first tube, whereby said first and second tubes conduct alternately, at least one electrode external of and adjacent to said tubes, a source of audio or higher frequency excitation potential coupled to the external electrode for applying to the gas within said tubes an excitation field of a potential level sufficient to stabilize the characteristics of said tubes and insufficient to sustain conduction between said internal electrodes, and a utilization circuit coupled to a principal electrode of either of said tubes for deriving pulses from said pulse generating circuit.

4. A stabilized pulse-generator circuit comprising a pair of gas-filled tubes, each having at least a cathode, an anode and a grid, characterized by, means for biasing the grid of each of said tubes to establish a predetermined breakdown potential for said tubes, a respective connection from the cathode of each of said tubes to ground, a resistor connecting the anode of a first one of said tubes to the positive terminal of a source of unidirectional potential, the potential of said terminal being greater than the breakdown potentials of said tubes, whereby said first tube is caused to conduct, with means including a resistor connecting the anode of the second tube to said positive terminal for causing said second tube to conduct to thereby produce a negative surge at the anode of the second tube, a condenser mutually connecting the respective anodes of the first and second tubes to couple said negative surge to said anode of the first tube for extinguishing said first tube, whereby said first and second tubes conduct alternately, at least one electrode external of and adjacent to said tubes, a source of audio or higher frequency excitation potential coupled to the external electrode for applying to the gas within said tubes an excitation field of a potential level sufficient to stabilize the characteristics of said tubes and insufficient to sustain conduction between the cathode and anode of

either tube, and a utilization circuit coupled to a principal electrode of either of said tubes for deriving pulses from said pulse generating circuit.

5. In a circuit employing a gas-filled tube including at least two internal electrodes, means for stabilizing the characteristics of said tube, said means comprising at least one electrode external of and adjacent to said tube, and a source of audio or higher frequency excitation potential coupled to the external electrode for applying to the gas within said tube an excitation field of a potential level sufficient to stabilize the characteristics of said tubes and insufficient to sustain conduction between said internal electrodes.

6. A stabilized pulse generating circuit comprising a pair of gas-filled tubes, each tube having at least an anode and a cathode, a source of tripping pulses and connections therefrom to the anode of each of said tubes for firing the latter, means including connections between the respective anodes of said tubes for extinguishing one tube upon the firing of the other, whereby said tubes fire alternately in response to said tripping pulses, at least one electrode external of and adjacent to said tubes, a source of audio or higher frequency excitation potential coupled to the external electrode for applying to the gas within said tubes an excitation field of a potential level sufficient to stabilize the characteristics of said tubes and insufficient to sustain conduction between the cathode and anode of either tube, and a utilization circuit coupled to a principal electrode of either of said tubes for deriving pulses from said pulse generating circuit.

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