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FIRING CIRCUITS FOR A COLD CATHODE GAS TUBE

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FIG. 1

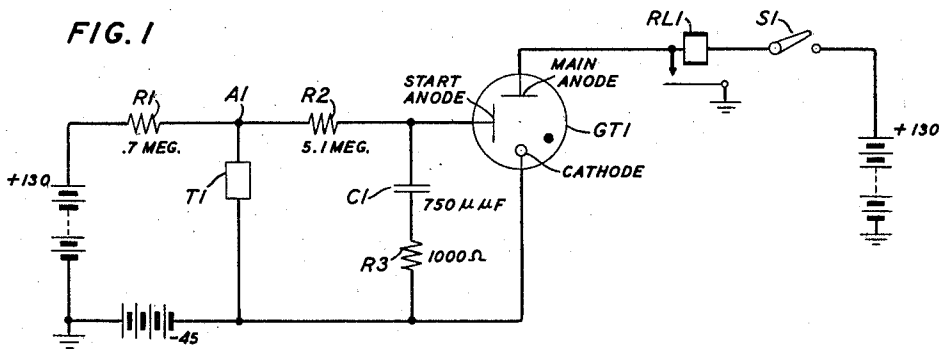


FIG. 3

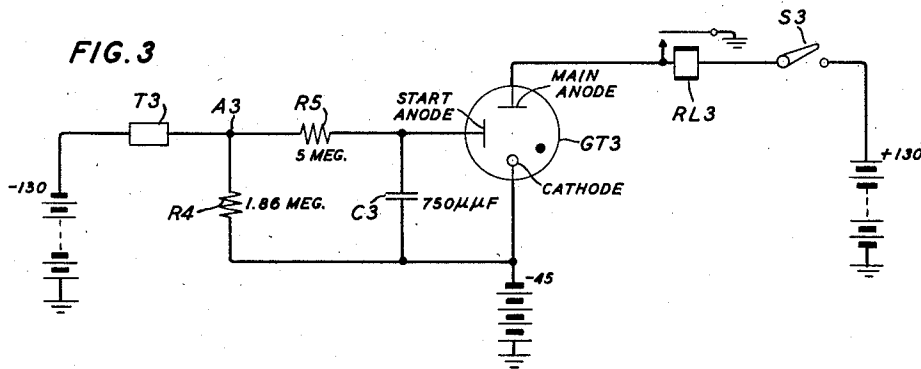
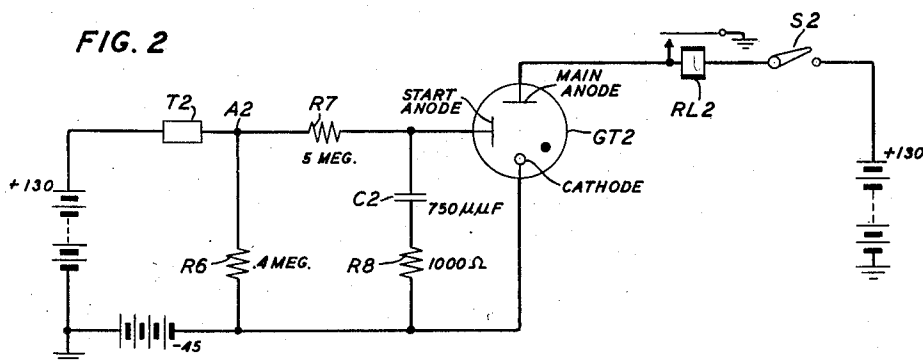


FIG. 2



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FIRING CIRCUITS FOR A COLD CATHODE GAS TUBE

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5 Claims. (Cl. 315—157)

This invention relates to circuits for firing a cold cathode gas tube and more particularly, to circuits which reliably fire a multi-element cold cathode gas tube as a minimum amount of control current is supplied thereto.

Circuits utilizing multi-element cold cathode gas tubes are well known in the art. A preliminary current, usually characterized as a control current or as a control signal, is supplied to an auxiliary element within the tube when it is desired to initiate conduction between the main elements therein. The current or signal applied to the auxiliary element, commonly called the start anode, causes a preliminary ionization or breakdown within the tube which then, in turn, effects ionization or breakdown between the main elements.

It is an object of the invention to provide an improved circuit for firing multi-element cold cathode gas tubes.

It is a further object of the invention to provide a circuit which will enable a multi-element cold cathode gas tube to fire as a minimum amount of control current is applied to its start anode.

It is a further object of the invention to provide a circuit in which a high impedance, low current device, such as a phototransistor, for example, can directly control the operation of a multi-element cold cathode gas tube without the necessity of any intervening current or voltage amplifiers.

The circuits of the present invention enable multi-element cold cathode gas tubes to be fired in response to the application of extremely minute currents from a controlling source, such as a phototransistor. This small control current may be as little as a few microamperes even though the tube with which it is associated requires control currents in the order of milliamperes to enable it to fire. This feature enables high impedance, low current sources such as phototransistors, photoelectric cells and other similar devices to control the firing of gas tubes without the necessity of an intervening amplifier. This represents a distinct advancement over the prior art arrangements wherein the device which controls the firing of cold cathode gas tubes has to supply a sufficient current to the tube to fire it, or else has to fire it with the aid of a current amplifier if its own current handling capabilities are insufficient.

The present invention utilizes a condenser connected across the control gap of a cold cathode tube in order to supply the necessary current to fire the tube. As the control device, a phototransistor herein, supplies an increased potential to the tube in an attempt to fire it, the condenser shunted across the control gap begins to charge. The charging current through the condenser, however, lowers the potential across the control gap so that the tube does not fire immediately. The voltage across the control gap rises as the condenser becomes more fully charged and a breakdown is initiated across this gap when the voltage reaches the critical potential for the tube. At this time, the condenser rapidly discharges through the ionized control gap and, in doing so, supplies enough current to en-

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able the tube to become sufficiently ionized so that it breaks down and conducts across its main gap.

It is a feature of the invention to shunt a condenser across the control gap of a cold cathode gas tube in order to enable the firing thereof to be controlled directly by a low current, high impedance element.

It is a further feature of the invention to connect a negative potential to the start anode of a cold cathode gas tube in order to fire the tube on lower control currents.

A complete understanding of this invention may be had from a study of the following detailed description and accompanying drawings in which:

Fig. 1 illustrates one preferred exemplary embodiment of the invention whose circuit fires the gas tube associated therewith in response to the absence of light on the phototransistor element of the circuit;

Fig. 2 illustrates another preferred exemplary embodiment of the invention whose circuit fires the gas tube associated therewith in response to the presence of light on the phototransistor element of the circuit; and

Fig. 3 illustrates another preferred exemplary embodiment of the invention whose circuit fires the gas tube associated therewith in response to the presence of light on the phototransistor element of the circuit.

In order that the invention may be disclosed in a clear and concise manner, all elements not necessary to an understanding thereof, and all control circuits and safety devices which would normally be incorporated in its commercial embodiment have been omitted.

Fig. 1 discloses a circuit in which the gas tube GT1 will fire across its main gap when light is removed from phototransistor T1. Resistor R1 is connected in series with phototransistor T1 across a positive 130-volt battery and a negative 45-volt battery so as to form a voltage-divider circuit. The phototransistor T1 may be of any type suitable for the purpose so long as it has the characteristic of lowering its impedance when light impinges on its face, and of raising its impedance when light is removed therefrom. This characteristic of the phototransistor causes the terminal A1 on the voltage divider to assume different potentials at different times depending upon whether or not light is currently impinging on the face of the phototransistor.

The impedance of the phototransistor T1 is low when light impinges thereon, with the result that terminal A1 assumes a reduced potential since the impedance of the phototransistor is relatively low in comparison with the impedance of resistor R1. This lowered potential at terminal A1 is applied to the condenser C1 and to the start anode of the tube GT1, but it is ineffective to cause ionization therein since the potential is below the critical voltage required to initiate ionization between the start anode and the cathode in the tube. The circuit remains in this condition and no further action takes place as long as light continues to impinge on the face of the phototransistor. The gas tube in Fig. 1, as well as in the other figures, may be of any suitable type, such as a Western Electric type 376B.

When light is removed from the phototransistor, its impedance rises considerably, which causes the potential at terminal A1 to rise due to the fact that the impedance of the phototransistor is now much greater than that of resistor R1. This raised potential at terminal A1 is applied through resistor R2 to the start anode and to condenser C1 which now commences to charge. The charging current produces an IR drop across resistor R2 so that the potential actually applied to the start anode at this time is still not sufficient to fire the tube. The potential applied to the start anode begins to rise as the condenser charges, and when said condenser has obtained a certain charge, the voltage at the start anode becomes sufficient to ionize

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the gap between the start anode and the cathode, thereby causing an ionization current to flow between these two elements.

The ionization between the start anode and the cathode, hereinafter referred to as the starter gap, creates a low impedance path between these two elements, with the result that condenser C1 now begins to discharge there-through with its discharge current being limited mainly by the low impedance of resistor R3. This current causes further ionization of the gas within the tube, with the result that ionization and conduction takes place between the main anode and the cathode, hereinafter called the main gap. The ionization of the main gap causes relay RL1 in series therewith to operate and lock over its main contacts. The operation of the relay quite obviously may be used to effect any further circuit operations that may be desired. The ground on the contacts of the relay extinguishes the main gap of the tube by short-circuiting it. Switch S1 is opened when it is desired to release the relay.

Condenser C1 is a necessary component of the above circuit since the tube would never fire across its main gap without it due to the following considerations. With the condenser omitted, the starter gap would only ionize slightly as the increased potential from terminal A1 is applied through resistor R2 to the start anode upon the cessation of light impinging on the face of phototransistor T1. This ionization, which is proportional to the starter gap current, would be extremely small and would ionize relatively few gas molecules because of the extremely high impedance of resistor R2 and the low current handling capacity of the phototransistor. It is an inherent characteristic of gas tubes of the type used herein by way of example that the current in the starter gap must be in the order of 200 microamperes or more before the tube will become sufficiently ionized to enable breakdown of the main gap. Each microampere of current flowing through resistor R2 produces approximately a 5-volt drop and, therefore, it is readily seen that resistor R2 is incapable of instantaneously supplying sufficient starter gap current to effect ionization of the main gap. It may appear from this explanation that it is merely the high impedance of resistor R2 that prevents the circuit from operating without the presence of the condenser. Such, however, is not the case. It is the low current carrying capacity of the phototransistor and not the high impedance of resistor R2 that prevents the circuit of Fig. 1 from operating without the presence of condenser C1. Resistor R2 is of a high impedance only in order to protect the phototransistor T1 from being destroyed by an excess of current flowing therethrough.

Fig. 2 illustrates a circuit similar to that of Fig. 1 with the exception that the gas tube GT2 fires in response to light impinging on the face of the phototransistor rather than in response to the absence of light thereon. Resistor R6 and phototransistor T2 are connected in series so as to form a voltage-divider network connected across the terminals of a 130-volt positive battery and a negative 45-volt battery, which are connected in series aiding. Terminal A2 on the voltage divider is at a low potential when there is no light on phototransistor T2, due to the fact that the impedance of resistor R6 is low in comparison with the impedance of the phototransistor, which has a high impedance when no light impinges thereon. In this condition, the voltage drop across resistor R6 is so small in comparison with the voltage drop across phototransistor itself that insufficient voltage is applied through resistor R7 to fire the starter gap of the tube GT2.

When light impinges on the face of the phototransistor T2 its impedance decreases, with the result that the potential at terminal A2 greatly increases since the impedance of resistor R6 now comprises a greater percentage of the total impedance of the voltage-divider network. This increased potential on terminal A2 is applied through resistor R7 to charge condenser C2, and to fire the tube as the

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condenser discharges in a manner similar to that described in connection with Fig. 1. The operation of relay RL2 in response to the firing of the tube can effect whatever further circuit operations or control functions that may be desired. Switch S2 is released when it is desired to release the relay. The ionization of the main gap in the tube ceases when the relay is operated, due to the fact that the ground applied to the main anode of the tube from the make contact on the relay effectively short-circuits its main gap.

Fig. 3 illustrates a circuit in which the tube GT3 is fired in response to the presence of light on the phototransistor T3. In this case phototransistor T3 and resistor R4 are connected in series across a negative 130-volt battery and a negative 45-volt battery, which are connected in series opposing so as to give an effective voltage of 85 volts across the voltage-divider network comprising the phototransistor T3 and resistor R4.

Terminal A3 is at a relatively low negative potential when the phototransistor is in its dark condition since the impedance of resistor R4 is low in comparison with that of the phototransistor. In this condition the voltage drop across the phototransistor is much greater than that across resistor R4, with the result that a lowered potential is supplied from terminal A3 through resistor R5 to condenser C3, and to the start anode of the tube GT3 so that the tube does not ionize at this time.

When light impinges on the face of the phototransistor T3, its impedance decreases greatly and a greater percentage of the potential applied to the voltage-divider network is now across resistor R4. This increased potential is applied from terminal A3 through resistor R5 to the start anode of the tube, and to condenser C3 which now begins to charge in a negative direction. The potential applied to the start anode rises in a negative direction and after it becomes sufficiently negative a discharge is initiated between the start anode and the cathode, with current flowing from the start anode to the cathode. Capacitor C3 now begins to discharge through this path. A discharge is also initiated between the main anode and the start anode at this time since the potential difference between the main anode and start anode is greater than the potential difference between the main anode and cathode. The current in the two discharge paths discharges condenser C3 and produces an IR drop in resistor R5 which reduces the potential of the start anode to a value equal to or lower than that of the cathode, so that the discharge between the start anode and the cathode extinguishes and the discharge between the start anode and the main anode transfers from the start anode to the cathode, thereby fully ionizing the main gap of the tube. Relay RL3 in series with the main anode operates and extinguishes the main gap of the tube in a manner described hereinbefore. The operation of the relay can then effect whatever further control functions that may be desired. Switch S3 is opened when it is desired to release the relay.

It is to be understood that the above-described arrangements are merely illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention. For example, resistor R2 in Fig. 1 need not be associated with a phototransistor but instead, could be connected directly to a source of potential when it is desired to fire the tube. The resulting circuit would insure that the tube would fire under adverse operating conditions such as weak batteries, high resistance relay contacts, and other such defects which normally would result in insufficient starter gap current being supplied to the tube to enable it to fire.

What is claimed is:

1. In a circuit for a cold cathode gas tube having a plurality of electrodes including a cathode, a main anode, and a start anode, a condenser interconnecting said start

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anode and said cathode, a first source of potential connected to said cathode, a second source of potential connected to said main anode, said start anode having connected thereto a third source of potential that is negative with respect to said first and second sources of potential for initiating a discharge between said start anode and said cathode and between said start anode and said main anode.

2. In a circuit for a cold cathode gas tube having a plurality of electrodes including a cathode, a start anode, and a main anode, a first source of potential connected to said cathode, a resistor interconnecting said start anode with a second source of potential that is negative with respect to said first source whereby a discharge is initiated between said start anode and said cathode as well as between said start anode and said main anode to which is connected a third source of potential that is positive with respect to said first source, and means including a condenser connected between said start anode and said cathode to cause said initiated discharges to effect a discharge between said cathode and said main anode.

3. In a circuit for a cold cathode gas tube having a plurality of electrodes including a cathode, a start anode, and a main anode, said tube being of the type in which a discharge of sufficient intensity between said start anode and said cathode effects a discharge between said main anode and said cathode, a first source of potential connected to said cathode, a resistor interconnecting said start anode with a second source of potential that is negative with respect to said first source whereby a discharge is initiated between said start anode and said cathode and said start anode and said main anode to which is connected a third source of potential that is positive with respect to said first source, and means including a condenser connected between said start anode and said cathode to cause said initiated discharges to become of sufficient intensity to effect a discharge between said cathode and said main anode.

4. In a light detection circuit, a cold cathode gas tube

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having a plurality of electrodes including a cathode and a start anode, a light responsive element and a first impedance connected in series across a first source of potential, a second impedance interconnecting said start anode with the junction of said light responsive element and said first impedance, a condenser interconnecting said start anode and said cathode, a second source of potential connected to said cathode, means for applying to said start anode a potential that becomes increasingly more negative with respect to the second source as light impinges on said light responsive element for initiating a discharge between said start anode and said cathode.

5. In a light responsive circuit, a cold cathode gas tube having a plurality of electrodes including a cathode, a start anode, and a main anode, said tube being of the type in which a discharge of sufficient intensity between said start anode and said cathode effects a discharge between said main anode and said cathode, a first source of potential connected to said cathode, a phototransistor connected in series with a first impedance across a second source of potential, a second impedance interconnecting said start anode with the junction of said phototransistor and said first impedance whereby a low current potential that is negative with respect to said cathode is applied to said tube during the presence of light on said phototransistor to initiate a discharge between said start anode and said cathode, and means including a condenser connected between said start anode and said cathode to cause said initiated discharge to become of sufficient intensity to effect a discharge between said cathode and said main anode to which is connected a third source of potential that is positive with respect to said first source of potential.

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