March 1, 1960 H. E. RUEHLEMANN 2,926,610

ELECTRIC TIME FUZE

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FIG. 1.

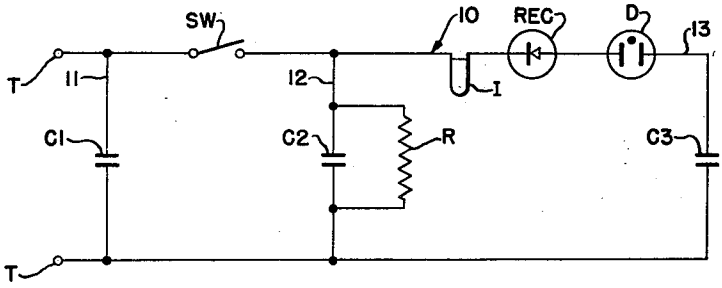


FIG. 2.

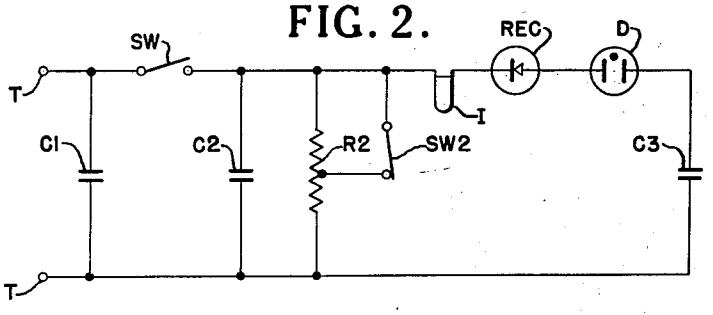


FIG. 3.

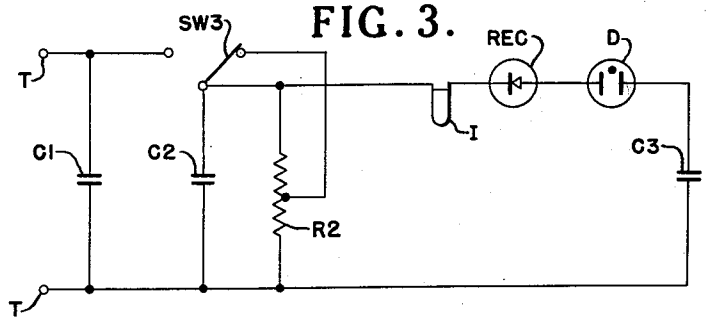
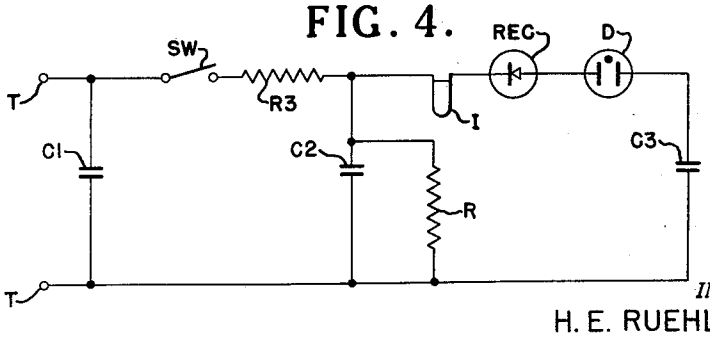


FIG. 4.



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ELECTRIC TIME FUZE

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This invention relates to a fuze and more particularly to an electrically controlled fuze for use in an ordnance missile such, for example, as a projectile, rocket, bomb or the like for exploding the missile in predetermined time delayed relation with respect to impact thereof with a target or in time delayed relation automatically with respect to subsequent impacts of the missile with subsequent targets after penetration of a first target surface.

Heretofore, fast and slow burning pyrotechnic elements have been employed in ordnance missiles for delaying the ignition and explosion of the main charge therein after impact of the missile with a target. Such time delay elements have not proven to be entirely satisfactory for the reason that once the fuze is assembled the time delay period remains fixed and can not be varied or adjusted at the time of firing or launching of the missile or automatically controlled upon impact of the missile with a target thereby rendering such missiles useless particularly when used against certain types of targets.

The present invention provides basic advantages over the prior art pyrotechnic time delay elements for the reason that the new and improved arrangement provides means for selecting the desired time delay period in accordance with the type of target subjected to attack and in which additional means are employed whereby the time delay period is controlled automatically with respect to subsequent impacts of the misisle with subsequent targets after penetration of a first target surface.

An object of the present invention is to provide a new and improved electric fuze for an ordnance missile in which means are provided for automatically obtaining various delayed ignitions of the igniter element arranged within the fuze depending upon the type of target subjected to attack.

Another object of the invention is the provision of a new and improved electric fuze for an ordnance missile in which storage means are provided for causing the missile to be fired at different time intervals after impact thereof with a target by varying the initial charge of the storage means.

A further object of the invention is the provision of a new and improved RC delay circuit arrangement for an ordnance missile whereby an optimum delay is manually selectable and in addition thereto the circuit response is a function of the actual impact.

A still further object resides in the provision of an electric time fuze in which the difference in the conductivity of a rectifier in reverse directions is utilized to control the firing of the fuze.

Other objects and many of the attendant advantages of the invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a diagrammatic representation of an electrical fuze circuit constructed in accordance with the preferred embodiment of the present invention; and

Figs. 2, 3 and 4 are views in diagrammatic form showing alternate arrangements of the device of Fig. 1.

Referring now to the accompanying drawings in which like reference characters designate corresponding parts throughout the several views and more particularly to Fig. 1 thereof, the numeral 10 generally designates a new and improved RC time delay fuze arrangement comprising three parallel connected circuit branches 11, 12 and 13, and a condenser respectively arranged in each branch and indicated by the reference characters C1, C2 and C3.

The condenser C1 is charged with electrical energy in any suitable manner such, for example, as by a battery connectable to the terminals T of branch 11 or by a charging device (not shown) before the missile is fired from a gun or launched from a launching rack, or as the missile is propelled through the barrel of a gun or along a launching rack, as the case may be, it being understood, however, that by varying the values of the charge in condenser C1 a longer or shorter time delay period may be obtained before the fuze will function and explode the missile after impact of the missile with a target.

Condenser C2 in branch 12 has a resistor R connected thereacross. Branch 13 also is connected across condenser C2 and has arranged therein and connected in series with respect to each other an electroresponsive detonator or igniter I, rectifier REC, cold cathode diode or glow tube D, and condenser C3.

Rectifier REC may be of any suitable type such, for example, as germanium rectifiers, having a forward resistance of the order of 10 ohms and a reverse resistance in the order of 100,000 ohms. Igniter I preferably has a resistance in the ratio of 1 to 10,000 with respect to the reverse resistance of the rectifier for reasons more fully to appear hereinafter in the description of the operation of the circuit of Fig. 1.

Glow tube D in a specific circuit arrangement has a breakdown potential in the order of 100 volts and a conduction sustaining potential in the order of 60 volts, the tube breaking down and conducting when the voltage across the elements exceeds approximately 100 volts and the tube being extinguished when the voltage thereacross falls below approximately 60 volts.

Branch 11 includes a switch SW which may be of any well known type of a normally open impact responsive switch which is adapted to be closed momentarily in response to an inertial force such, for example, as the setforward force resulting from impact of the supporting missile with a target.

During this impact of the missile with a target, switch SW closes in response thereto and condenser C2 is charged substantially instantaneously by the normally charged condenser C1. Concurrently therewith current from condenser C1 passes through resistor R and also through path 13 whereupon condenser C3 is charged through igniter I, rectifier REC and diode D in series therewith. By the specific arrangement of the rectifier in the circuit as disclosed the high resistance is effective during the transfer charging period from C1 to C3 and thus the voltage dissipated across the igniter is low in value and therefore such voltage is of insufficient strength to fire the igniter.

When switch SW opens following the impact, the switch being open, for example, for an interval in the order of one millisecond, the charge on condenser C2 discharges through resistor R and through path 13 thus continuing the charging of condenser C3 until the difference in the voltages on condensers C2 and C3 becomes less than the conduction sustaining potential of tube D, this being 60 volts in the specific example aforementioned, whereupon the tube is extinguished and further charging of condenser C3 ceases.

Condenser C2 continues to discharge through resistor R and when a predetermined period of time has elapsed

following the impact and corresponding to a selected time delay period controlled principally by the time constant, RC, of condenser C2 and resistor R, the charge in C2 is drained sufficiently to allow the diode D to conduct again but this time in the reverse direction, the difference in the voltages of condensers now being equal to or exceeding the breakdown potential of tube D of approximately 100 volts, and thus when this reverse transfer charging process occurs the voltage dissipated at the igniter I is of a high degree owing to the low forward resistance of the rectifier and is of sufficient strength to fire the igniter thereby to explode the missile.

However, it will be apparent that by varying the voltage in the storage condenser C1, the delay time at which the fuze will function may be varied, the charge transferred to condenser C2 being of more or less voltage depending on the voltage of condenser C1, a higher voltage resulting in a lower delay time, for example, as in the case of prior art RC time delay circuits. It will be obvious, however, that the selection of the delay time period is determined in accordance with the kind and structural arrangement of the target subjected to an attack.

Furthermore, it will be understood that during the period of time that the switch SW is closed, the time constant for discharging the condenser C2 through resistor R is increased by the capacity of C1 thereby increasing the delay time before the ignition of the igniter occurs. Thus should the projectile strike and penetrate a target composed of thick material such, for example, as a fortification or armor plate of a ship, the impact switch SW remains closed a longer period of time than when the missile strikes a target composed of thin material. Thus it will be apparent that the ignition time of the igniter will be automatically increased by the resulting higher time constant $(C1+C2)R$.

An additional effect may be obtained by the aforesaid circuit arrangement, particularly when the missile is used for the destruction of other targets such, for example, as a house or ship or the like, and in such cases the missile is adapted to penetrate the roof and floor structure of a house target or several armor plates of a ship, as the case may be. It will be apparent from the foregoing, that by selecting a voltage which results in a delay time longer than the time necessary for the projectile to strike and penetrate the aforesaid roof structure or one of the plates, as the case may be, and to continue on through the floor structure or second plate structure, the circuit will not cause the fuze to function and explode the missile at the time of the second impact for the reason that when the second impact occurs, the switch SW is closed again in response thereto whereupon condenser C2 which has been substantially discharged in response to the first impact will be recharged by C1 a predetermined amount and thus during the aforesaid second charging cycle ignition of the igniter I is delayed automatically in response to the aforesaid second impact.

Furthermore, the aforesaid fuze arrangement may be advantageously employed in submarine warfare. When used against such targets a relatively low charge in condenser C1 results in a longer delay, for the reason, that upon water impact switch SW is closed, and will remain closed during the travel of the missile through the water toward the submarine target and thus a longer delay time period will occur in case of a near-miss whereupon the likelihood of the missile being exploded at or near the target will be greatly increased. In such case, switch SW being closed, the voltage on condenser C3 rises above the voltage on condenser C2 in an amount equal to or exceeding the breakdown potential of glow tube D when the predetermined time delay has elapsed and the charge on condenser C3 is discharged in the forward direction through the rectifier REC and through the detonator whereupon the fuze is fired, the charge on condensers C1 and C2 being dissipated through resistor R and passed in part to condenser C3 whereas the charge simultaneously developed in condenser C3 is retained therein until breakdown of the glow tube. However, should the missile strike the submarine during the water descent thereof the impact switch SW will open in response to the deceleration of the missile as the missile strikes and penetrates the outer shell of the submarine and thus the time constant is diminished thereby causing automatic ignition of the igniter in a shorter period of time after impact and penetration of the target by the missile.

Referring now to the fuze arrangement of Fig. 2, an additional delay action is accomplished by employing a normally closed switch SW2 in addition to switch SW, Fig. 1, the switch being shunted across a portion of a resistor R2. Such delay action occurs as the switch is moved from the initial closed position to an open position and thence back to the initial position before the charging circuit from C2 through resistor R2 and to C3 is completed.

Assume, for example, that R2 is center tapped at the connection with SW2 and is twice the resistance of R of Fig. 1. When switch SW closes and switch SW2 opens on impact, the time constant of the charging circuit is $(C1+C2)R2=(C1+C2)\ 2R=2(C1+C2)R$ which is twice the corresponding time constant for Fig. 1. Accordingly, the time required to place the same charge on condenser C2 when switch SW opens in the case of Fig. 2 is approximately twice that required in Fig. 1. However, when switch SW is closed for the same interval in each case, the resulting voltage on C2 in Fig. 2 is correspondingly less and a longer time delay results and the circuit of Fig. 2 operates in the same manner as Fig. 1 when switch SW2 becomes closed following the impact.

In reference to Fig. 3 of the drawings, the arrangement and operation thereof is substantially identical as that of Fig. 2 except that a double action switch SW3 is substituted for switches SW and SW2, the operation of the circuits of Figs. 2 and 3 otherwise being the same.

In the arrangement of Fig. 4, resistors R and R3 are employed as delay action means, resistor R3 is disposed between condensers C1 and C2 for delaying the build up of condenser C2 by C1 as the switch SW functions to a closed position as hereinbefore set forth. By reason of this arrangement, condenser C2 is charged to a lower voltage than in Fig. 1 for the same closure time of switch SW with the result that a longer delay time is provided, it being recalled that the delay time is longer for lower voltages and shorter for higher voltages.

It will be obvious in view of the foregoing that by selecting the proper value of the initial charge, and the values of capacitance and resistance the desired time delay may be obtained. Furthermore, the present invention provides a new and improved RC delay fuze arrangement the time constant of which may be changed by varying the size of the resistor or resistors, as the case may be, or by varying the size of both the resistors and condensers, and in which an optimum delay is manually selectable, and in addition thereto the circuit response is a function of the actual impact of the missile with a target.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An electric time fuze comprising, in combination, an electrical energy source having a decreasing potential level thereacross, an electrical circuit connected across said source and including an electroresponsive detonator,

a glow tube, an energy storage device and a rectifier having low energy conductance in one direction of an amount insufficient to effect ignition of said detonator whereby the energy passed therethrough from said source is stored in said storage device until the potential across said storage device becomes substantially equal to the sustaining potential of said glow tube, said rectifier having high energy conductance in the opposite direction for discharging the energy stored in said device through said detonator in an amount sufficient to fire said detonator when the potential across said device exceeds the potential across said source by an amount necessary to render said glow tube conductive.

2. An electric time fuze of the character disclosed for use in a missile comprising, in combination, a first normally discharged condenser, a source of electrical energy, impact responsive switch means for momentarily transferring energy from said source to said condenser during the moment of impact of said missile with a target, a first discharge path for said condenser including a resistance for causing the voltage on the condenser to decrease at a predetermined rate of time, and a second discharge path for said condenser including an electroresponsive detonator, a rectifier, a glow tube and a second condenser connected in series across the first condenser in the order named, said rectifier having low conductance in the direction of said discharge insufficient to ignite said detonator whereby the energy passed therethrough is stored in the second condenser until said glow tube is extinguished as the difference in the voltages on the condensers become equal to or less than the sustaining potential of the glow tube, said rectifier having high conductance in the reverse direction to discharge sufficient energy therethrough from said second condenser to fire said detonator, said glow tube being rendered conducting to discharge said energy from the second condenser when the difference in voltages of the condensers increases to the breakdown potential of the tube upon continued discharge of the first condenser following said extinguishing of the glow tube.

3. In an electric time fuze of the character disclosed for use in an ordnance missile, the combination of a normally charged condenser, an electroresponsive detonator, impact responsive switch means, a second condenser operatively connected to said switch means and to said normally charged condenser and adapted to be charged from the charged condenser as the switch means operates in response to impact of said missile with a target, a resistance connected to said second condenser for causing the voltage on the condenser to decrease at a predetermined rate of time, a third condenser operatively connected to said first and second condensers and charged thereby, and a rectifier and a glow tube connected to said second and third condensers for passing energy discharged from said first and second condensers to said third condenser through the detonator in an amount insufficient to fire the detonator, said rectifier being adapted to discharge the energy from said third condenser through the detonator and rectifier to the second condenser in an amount sufficient to fire the detonator when the voltage on said third condenser exceeds the potential of said second condenser by a predetermined amount to render the glow tube conductive.

4. An electric time fuze of the character disclosed for use in a missile comprising, in combination, a normally charged condenser, a normally discharged condenser, a normally open discharge path including an impact responsive switch means disposed between said condensers for momentarily transferring energy from said first condenser to said second condenser as the switch is actuated from an initial position to a moved position in response to the impact of the missile with a target, a discharge path for the second condenser including a resistance for causing the voltage on the second condenser to decrease at a predetermined rate of time, and a second discharge path for the second condenser including an electroresponsive detonator, a rectifier, a glow tube, and a third condenser connected in series therein, said rectifier having low conductance in the direction of said discharge therethrough from said second condenser insufficient to ignite said detonator whereby the energy passed therethrough is stored in the third condenser until said glow tube is extinguished as the difference in the voltages on the second and third condensers become equal to or less than the sustaining potential of the tube, said rectifier having high conductance in the reverse direction sufficient to discharge energy therethrough from said third condenser to fire said detonator, said glow tube being rendered conducting to discharge said energy from the third condenser when said difference in the voltages of the second and third condensers increases to the breakdown potential of the tube upon continued discharge of the second condenser following said extinguishing of the glow tube.

5. An electric time fuze of the character disclosed for use in an ordnance missile comprising, in combination, a first normally charged condenser, a second condenser, means including a normally open charging circuit for transferring energy from said first condenser to said second condenser as the circuit is closed, impact responsive switch means in said circuit for closing the circuit momentarily as the switch is actauted from an initial position to a moved position in response to impact of said missile with a target, a first discharge path for said second condenser comprising a resistance for causing the voltage on the second condenser to decrease at a predetermined rate of time, a second discharge path for said second condenser, an electroresponsive detonator in said second discharge path, a rectifier in said second discharge path in series with said detonator, a glow tube in said second discharge path in series with said detonator and rectifier, a third condenser in said second discharge path and connected in series therein with the second condenser, detonator, rectifier and glow tube in the order named and charged therethrough by said first and second condensers as the circuit is closed and by said second condenser when the circuit thereafter is opened, said rectifier having low conductance in the direction of said discharge therethrough to said third condenser insufficient to ignite said detonator whereby the energy passed therethrough is stored in the third condenser until said glow tube is extinguished as the difference in the voltages on the second and third condensers becomes equal to or less than the sustaining potential of the tube, said rectifier having high conductance in the reverse direction sufficient to discharge energy therethrough from said third condenser to fire said detonator, said glow tube being rendered conducting to discharge said energy from the third condenser when said difference in voltages of the second and third condensers increases to the breakdown potential of the tube upon continued discharge of the second condensers following said extinguishing of the glow tube.

6. An electric fuze for use in an ordnance missile comprising a first condenser having a charge thereon received during impact of the missile with a target, an electroresponsive detonator, a rectifier having a low forward resistance and a high reverse resistance, a second condenser, a glow tube, circuit means for effecting charging of said second condenser from said first condenser through said detonator, said glow tube and in the reverse direction through said rectifier in an amount less than the sustaining potential on the glow tube and insufficient to fire said detonator, and a discharge path for said first condenser for reducing the voltage thereon in predetermined time delayed relation to said impact, said circuit means forming a discharge path for said second condenser for discharging said charge thereon through said detonator and in the forward direction through said rectifier in an amount exceeding the sustaining potential of the glow tube and sufficient to fire the detonator when

the voltage on the second condenser exceeds the voltage on the first condenser by a predetermined amount.

7. An electric time fuze of the character disclosed for use in an ordnance missile comprising first, second and third condensers, circuit means for charging the first condenser to a predetermined potential as the missile is launched, impact responsive means for momentarily transferring energy from said first condenser to said second and third condensers during each of a series of impacts of the missile with a plurality of targets, an electroresponsive detonator, and a rectifier and a glow tube conected in series in the charging path of the third condenser and connected in series circuit with the third condenser across the second condenser, and a discharge path for said second condenser for reducing the voltage thereon in predetermined time delayed relation to each of said impacts, said rectifier having a low forward resistance and a high reverse resistance, said rectifier being connected in said series circuit with said reverse resistance thereof opposing charging of the third condenser and limiting the time rate of charge thereof to a value insufficient to fire said detonator until the voltage on said condensers are substantially equal and the glow tube is extinguished, said forward resistance of the rectifier being sufficiently low to fire the detonator by the discharge of said third condenser therethrough when the voltage on the second condenser has dropped to a predetermined value below the voltage on the third condenser and said glow tube is rendered conductive following the last of said impacts.

8. An electric time fuze of the character disclosed for use in a missile comprising, in combination, a first normally discharged condenser, a source of electrical energy, impact responsive switch means for momentarily transferring energy from said source to said condenser during the moment of impact of said missile with a target, a first discharge path for said condenser including a resistance for causing the voltage on the condenser to decrease at a predetermined rate of time, a second discharge path for said condenser, a second condenser in said second discharge path and connected in series therein with said first condenser and charged by said voltage as the first condenser is discharged, an electroresponsive detonator in said second discharge path including a rectifier and glow tube connected in series therein with the first condenser in the order named, a normally closed impact responsive switch means in said first discharge path and shunted across a portion of said resistance for momentarily increasing the effect in resistance in the first discharge path as the normally closed impact switch means opens momentarily during said impact of the missile, said rectifier having low conductance in the direction of said discharge therethrough to the second condenser insufficient to ignite said detonator whereby the energy passed therethrough is stored in the second condenser until said glow tube is extinguished as the difference in the voltages on the condensers becomes equal or less than the sustaining voltage of the glow tube, said rectifier having high conductance in the reverse direction sufficient to discharge energy therethrough from said second condenser to fire said detonator, said glow tube being rendered conducting to discharge said energy from the second condenser when the difference in voltages of the condensers increases to the breakdown potential of the tube upon continued discharge of the first condenser following said extinguishing of the glow tube.

9. An electric time fuze of the character disclosed for use in a missile comprising, in combination, a first normally discharged condenser, a resistance connected across said condenser, a source of electrical energy, impact responsive switch means shunted across a portion of said resistance and connected to said source for momentarily transferring energy from said source to said condenser and momentarily increasing the effective value of said resistance during the movement of impact of said missile with a target, a first discharge path for said condenser including the remaining portion of said resistance for causing the voltage on the condenser to decrease at a predetermined rate of time when said first resistance portion is shunted following impact, a second discharge path for said condenser, a second condenser in said second discharge path and connected in series therein with said first condenser and charged by said voltage as the first condenser is discharged, an electroresponsive detonator in said second discharge path including a rectifier and glow tube connected in series therein with the second condenser in the order named, said rectifier having low conductance in the direction of said discharge therethrough to the second condenser insufficient to ignite said detonator whereby the energy passed therethrough is stored in the second condenser until said glow tube is extinguished as the difference in the voltages on the condensers becomes equal or less than the sustaining voltage of the glow tube, said rectifier having high conductance in the reverse direction sufficient to discharge energy therethrough from said second condenser to fire said detonator, said glow tube being rendered conducting to discharge said energy from the second condenser when the difference in the voltages of the condensers increases to the breakdown potential of the tube upon continued discharge of the first condenser following said extinguishing of the glow tube.

10. An electric time fuze of the character disclosed for use in an ordnance missile comprising first, second and third condensers, circuit means for charging the first condenser to a predetermined potential as the missile is launched, impact responsive circuit means for momentarily transferring energy from said first condenser to said second and third condensers during each of a series of impacts of the missile with a plurality of targets, resistive means in the charging paths of the second and third condensers for limiting the time rate of said transfer of energy thereto, an electroresponsive detonator, a rectifier and a glow tube connected in series in the charging path of the third condenser and connected in series circuit with the third condenser across the second condenser, and a discharge path for said second condenser for reducing the voltage thereon in predetermined time delayed relation to each of said impacts, said rectifier having a low forward resistance and a high reverse resistance, said rectifier being connected in said series circuit with said reverse resistance thereof opposing charging of the third condenser and limiting the time rate of charge thereof to a value insufficient to fire said detonator until the voltage on said condensers are substantially equal and the glow tube is extinguished, said forward resistance of the rectifier being sufficiently low to fire the detonator by the discharge of said third condenser therethrough when the voltage on the second condenser has dropped to a predetermined value below the voltage on the third condenser and said glow tube is rendered conductive following the last of said impacts.

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