

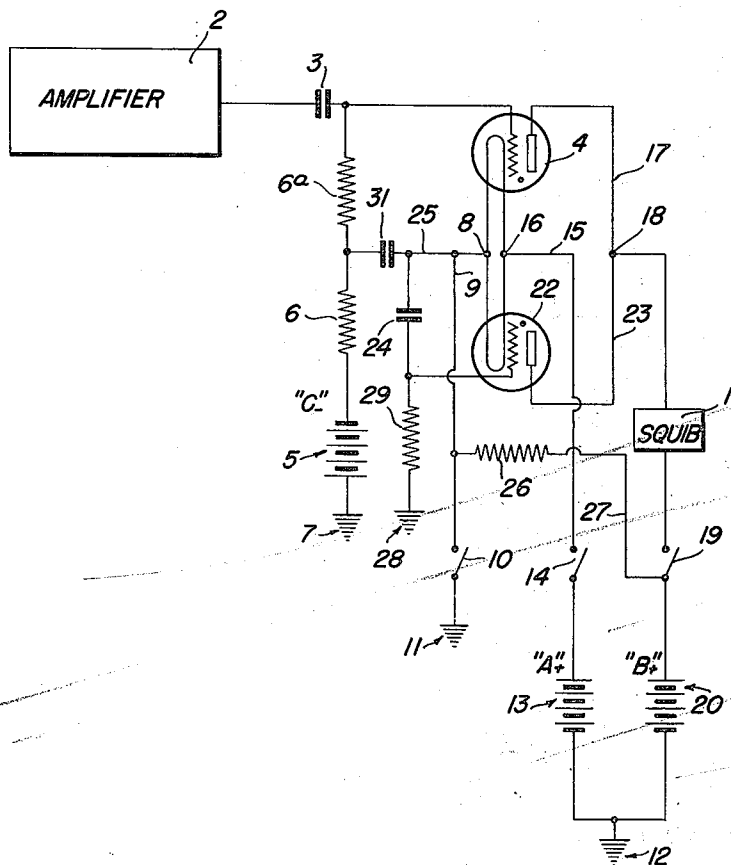
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TIME DELAY CIRCUIT

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TIME-DELAY CIRCUIT

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This invention relates to thermionic control circuits and has particular reference to a novel time delay control circuit employing a thermionic tube and which is timed under control of a combination of resistance and capacitance of predetermined values. The new timing device is of simple construction and is reliable and accurate in operation.

The time delay circuit of the invention may be used for various purposes but because of its simplicity and accuracy it may be employed to particular advantage as a safety device for explosive projectiles. Accordingly, for illustrative purposes, the invention will be described in the form of a time delay device for such projectiles, although it is to be understood that the invention is not limited to this use.

One object of the invention resides in the provision of a time delay device for use in explosive projectiles, which does not require the use of any moving part.

Another object of the invention is to provide a thermionic time delay circuit of novel construction, in which the time increment is controlled by the discharge of a condenser of predetermined capacitance through a predetermined resistance. In the preferred construction, the tube is of the hot-cathode gas-filled triode or tetrode type, in which conduction is normally prevented by the negative potential on the control grid of the tube. The negative potential is impressed upon the control grid by reason of the fact that the positive potential of a "B" battery is present at the cathode of the tube and the negative potential of the "B" battery is present at the control grid. The timing condenser is connected between the cathode of the tube and the control grid and is initially charged to full "B" battery voltage. When a tetrode thyatron type of tube is used, the second grid is grounded. The device is operated by actuating a switching means which prevents further charging of the condenser and permits the condenser to discharge through the resistance. When the condenser has discharged sufficiently to allow the potential on the grid to decline below a predetermined value, the tube becomes conducting so as to operate an electrical element, such as a detonating squib.

These and other objects of the invention may be understood by reference to the accompanying drawing, which illustrates one form of the new circuit for use as a safety device to detonate a squib in an explosive projectile at a predetermined time interval after the projectile is fired.

Referring to the drawing, the squib 1, as shown,

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is operable electrically by a radio apparatus comprising an amplifier 2 which may be connected to the output of an oscillator circuit of a proximity fuze (not shown), such as that disclosed in a copending application of M. A. Tuve et al., Ser. No. 471,388, filed January 6, 1943. The output of the amplifier is connected through a condenser 3 to the grid of a gas triode or thyatron 4. The grid is normally biased from the negative side of a "C" battery 5 through resistors 6 and 6a, the positive side of the battery being grounded, as shown at 7. One side of the filament constituting the cathode of the tube 4 is connected through a terminal 8, wire 9, setback switch 10, and ground connections 11 and 12 to the negative side of an "A" battery 13. The positive side of the "A" battery is connected through a setback switch 14 and wire 15 to a terminal 16 which is connected to the other side of the filament. The anode of the tube 4 is connected by a conductor 17 and a terminal 18 to one side of the squib 1, the other side of which is connected through a setback switch 19 to the positive side of a "B" battery 20, usually of 90–100 volts, the negative side of the "B" battery being grounded at 12. The switches 10, 14 and 19 may be of any desired construction in which the contacts are normally open and are locked in the closed position by a force of setback incident to firing the projectile.

It will be understood that the grid biasing of the gas triode 4 is normally such as to prevent conduction in the tube and consequent operation of the squib 1. When the projectile is fired from a gun, the resulting force of setback closes the switches 10 and 14 so as to connect the filament of tube 4 across "A" battery 13, and closes switch 19 so as to connect the anode through squib 1 to the positive side of the "B" battery. Accordingly, when a voltage pulse is delivered to the amplifier 2 from the oscillator (not shown) in response to proximity of a target, the pulse is amplified and acts to change the bias on the grid of tube 4 so as to cause the tube to become conducting, whereby the squib 1 is energized and explodes.

The time delay device of the present invention is illustrated in the form of a safety unit operable in conjunction with the radio controlled circuit previously described to cause detonation of the squib at a predetermined time interval after the projectile is fired, in the event that the radio controlled circuit fails to detonate the squib. The safety timing device comprises a second hot-cathode thyatron 22 of the triode or tetrode

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type, the filament of which is connected across terminals 8—16 in parallel with the filament of tube 4, the anode of tube 22 being connected by wire 23 to the terminal 18 and squib 1. The grid biasing circuit of tube 22 includes a condenser 24 connected at one side through a wire 25 to the conductor 9 which, in turn, is connected through a resistance 26 and wire 27 to the positive side of "B" battery 20. The negative side of the "B" battery is connected through ground leads 12 and 28 and a resistance 29 to the other side of condenser 24. Accordingly, the condenser 24 is charged to the full voltage of battery 20, and the grid of tube 22, which is connected between the resistance 29 and the condenser, has a negative charge of corresponding value. A condenser 31 is connected at one side between the resistors 6 and 6a and at the other side to wire 25.

When the setback switches 10, 14, and 19 close upon firing the projectile, the filament of tube 22 is connected across "A" battery 13, and the anode of tube 22 is connected through squib 1 and switch 19 to the positive side of the "B" battery. Due to the initial negative bias on the grid of the tube 22, the tube is prevented from becoming conducting and energizing the squib. However, as soon as switch 10 is closed, the charging circuit for the condenser 24 through resistor 29 ceases to act as such because wires 25 and 9 are now grounded, and the condenser commences to discharge through resistor 29 and the ground connection 28. When the condenser has discharged sufficiently to cause the negative potential on the grid of tube 22 to decline below a critical value, the tube becomes conducting and causes a current flow through squib 1 from the anode of the tube, with the result that the squib is exploded. The resistor 26 has a sufficiently high resistance that the load on "B" battery 20 is negligible when switch 10 is closed.

It will be observed that the new device acts as a safety unit to insure explosion of the projectile in the event that the projectile does not pass sufficiently close to the target to cause detonation of the squib through amplifier 2. Thus, the device prevents damage which might otherwise occur due to explosion of the projectile at the end of its flight on friendly territory. The time interval provided by the control circuit is preferably so adjusted as to include the estimated time required for the projectile to reach the target, in addition to a fixed time interval, such as five seconds, whereby the timing circuit cannot explode the projectile until after the radio apparatus has had an opportunity to function through amplifier 2. The time interval may be adjusted by varying the capacity of condenser 24 or the resistance of resistor 29. It has been found that by employing a resistor 29 of 20 megohms and a condenser 24 of .4 microfarad, a time delay of approximately 27 seconds is provided, although, of course, this specific delay is mentioned merely as an example, and in no way as a limitation. It will be understood that the tubes 4 and 22 are made sufficiently

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rugged to withstand the shocks incident to handling and firing a projectile.

What is claimed is:

1. In a detonator for an explosive projectile, a thyatron having a cathode, a control grid, and an anode, an electrically operable squib connected to the anode of the thyatron, a current source in circuit with the squib and the anode, the grid being normally biased to secure the thyatron from becoming conducting, an amplifier connected to the grid and operable to change the bias thereof to cause the thyatron to become conducting and fire the squib, a second thyatron having a cathode, a control grid, and an anode, means connecting the anode of the second thyatron to the squib, a biasing circuit for said last grid including a normally charged condenser for securing the second thyatron from becoming conducting, a resistor, and switching means responsive to firing the projectile for causing the condenser to leak through the resistor, whereby the second thyatron becomes conducting and fires the squib.

2. In an electrical self-destruction time delay device, a thyatron having a cathode, a control grid and an anode, an electrically operable detonator including a squib and connected to said anode, a grounded current source connected in circuit with said cathode, said anode, and said detonator, a condenser connected between the grid and the cathode, a resistor connected between the grid and the ground, means for charging the condenser from said source through said resistor, and means for rendering said charging means inoperative and causing the condenser to leak through the resistor, whereby the thyatron becomes conducting and fires the squib.

3. In an electrical self-destruction time delay device for an explosive projectile, a thermionic gas-containing tube having a cathode, a control grid, and an anode, an electrically operable detonator, including a squib and connected to said anode, a current source in circuit with the detonator and the anode and cathode, a biasing circuit connected to the grid and cathode and including a normally charged condenser for securing the tube against flashing, a resistor, said resistor having one terminal permanently connected to one side of the condenser and its other terminal permanently connected to the negative terminal of said current source, and switching means responsive to firing the projectile for causing the condenser to leak through the resistor, whereby the tube becomes conducting and fires the squib.

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