Sept. 29, 1959 R. MORISON ET AL 2,906,206

FIRING CIRCUIT

Filed Sept. 13, 1946

FIG. 1.

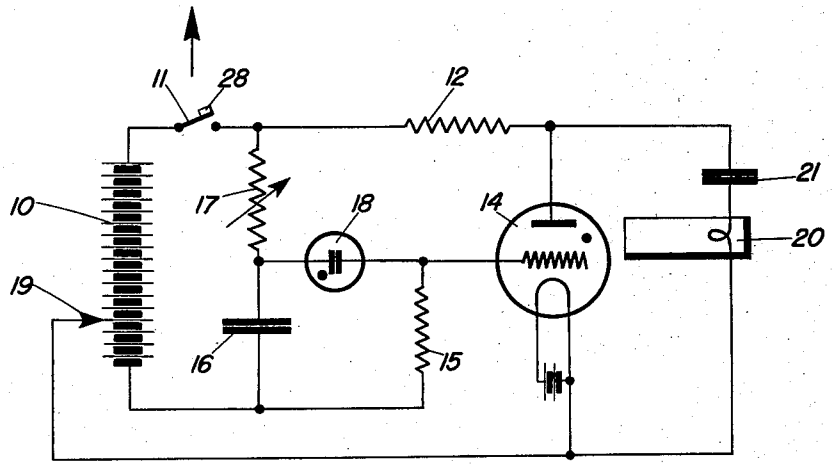
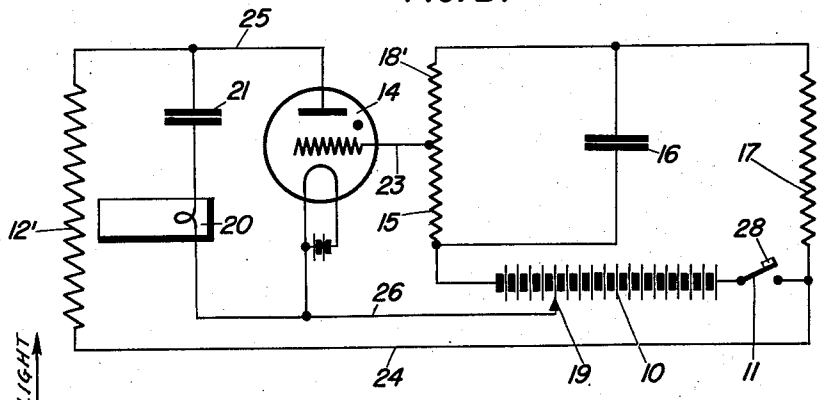


FIG. 2.



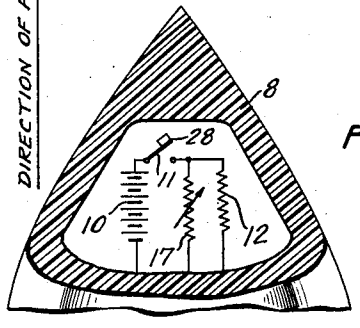


FIG. 3

INVENTORS
RODNEY MORISON
WALTER VANB. ROBERTS

BY M.O. Hayes
ATTORNEY

United States Patent Office 2,906,206 Patented Sept. 29, 1959

2,906,206

FIRING CIRCUIT

Rodney Morison, United States Navy, Pasadena, Calif., and Walter Van B. Roberts, Princeton, N.J., assignors to the United States of America as represented by the Secretary of the Navy

Application September 13, 1946, Serial No. 696,948

3 Claims. (Cl. 102—70.2)

This invention relates generally to circuits for predetermining the time of detonation of an ordnance missile having an electrical igniter. More specifically, it relates to circuits of the general type including an electron tube of the grid-controlled gas-filled category, of which the "Thyratron" is representative, and means for predetermining the time of discharge of the tube, the firing in turn serving to actuate an electrical igniter. The predetermining circuit is a novel and improved member of the general class which comprises resistors, condensers and a source of voltage, the condensers being charged through certain of the resistors at a controlled rate and discharging at the proper time to energize the electrical igniter.

One form of the novel circuit includes a neon glow-lamp or equivalent cold electrode tube containing a monatomic gas at low pressure in the discharge device input circuit, while another form relies solely on resistors and capacitors to fire the "Thyratron."

While the invention is not limited to any specific circuit dimensions, the parameters hereinbelow set forth in parentheses have been found practicable in one successful embodiment of the invention and are suggested for purposes of illustration.

For a better and further understanding of the invention together with other and further objects thereof, reference is made to the following description taken in conjunction with the appended claims and the accompanying drawings in which:

Fig. 1 is a circuit diagram of a firing circuit in accordance with the invention including a gas-glow tube in the "Thyratron" input circuit;

Figure 2 is a modified form of firing circuit in accordance with the invention but in which no glow lamp is employed; and

Fig. 3 is a fragmentary sectional view, of the nose of a projectile, showing schematically the means of initiating the fuze action upon set back produced by firing of the projectile.

Referring now specifically to Fig. 1, the circuit therein represented comprises a direct current source 10, of relatively high voltage, say of the order of one hundred volts, the positive terminal of which is connected through a switch 11 and a resistor 12 (2 megohms) to the plate of a "Thyratron" 14, and the negative terminal of which is connected to the grid of the "Thyratron" through a resistor 15 (1 megohm).

Bridged across battery 10, beyond the switch 11, is a series circuit comprising a condenser 16 (1 microfarad) and a variable resistor 17 (of the order of 4 megohms) in series. Condenser 16 charges from source 10 through resistor 17. Preferably resistor 17 is considerably higher in resistance than resistor 12.

Connected across condenser 16 is another series combination, comprising, a resistor 15 (1 megohm) and a neon-glow lamp 18. The electrodes of lamp 18 are normally maintained at the same potential difference as that prevailing between the terminals of condenser 16,

since normally there is substantially no current flow through resistor 15 and therefore no voltage drop therein. Moreover, the grid of the "Thyratron" is normally at the same potential with respect to the cathode as is the negative terminal of source 10 with respect to a tap 19.

The positive potential of the "Thyratron" cathode with respect to the grid may be adjusted by movable connection 19, shiftable to the proper point to provide whatever negative grid bias may be desired.

A work circuit consisting of an electrical igniter or firing squib 20 and a second condenser 21 (1 microfarad), in series, is coupled to the cathode-anode circuit of the "Thyratron." Condenser 21 thus charges slowly from source 10, through resistor 12, when switch 11 is closed.

It will be understood by those skilled in the ordnance art that a firing squib or electrical igniter conventionally comprises a high resistance wire imbedded in some inflammable chemical substance and has such operation that when the wire is heated the substance is ignited and the missile, in which the circuit is installed or in connection with which the circuit is operative is detonated.

Fig. 3 shows a means of initiating the fuze action. The fuze circuits are inoperative before firing, since both the input and work circuits are connected to the positive terminal of battery 10 through switch 11, which is initially open. A weight 28 is attached to the displaceable end of switch 11. When the projectile 8 is fired in the direction indicated by the arrow, set back forces act upon weight 28 to cause the closure of switch 11. The firing circuit is then in an operable condition and the timing action commences.

The operation of the circuit shown in Fig. 1 will now be described. When switch 11 is closed by set back forces upon firing, two significant phenomena occur. Condenser 21 acquires a charge from the battery at a rate controlled by its capacitance and by the resistance in the charging path including resistor 12, the charging current, however, always being insufficient to ignite the igniter 20 through which it flows. At the same time, condenser 16 also acquires a charge from source 10 through resistor 17. The circuits are so arranged that the time constant of the circuit comprising elements 10, 16, 17 is greater than that of the circuit comprising elements 10, 12, 21, 20, so that condenser 16 charges more slowly than condenser 21. This is a desired result, as condenser 21 should be substantially fully charged before the voltage across condenser 16 has become sufficiently high to cause lamp 18 to flash and tube 14 to fire.

Ultimately a glow-discharge in lamp 18 takes place, resulting in a drop of the impedance of the lamp down to its breakdown value and a partial discharge of condenser 16, through lamp 18 and resistor 15, down to a voltage near the extinction voltage of the lamp. Lamp 18 is a nonlinear impedance while resistor 15 is linear. The flow of current during the flashing of lamp 18 produces a voltage drop across resistor 15 which reduces the negative bias on the grid of the "Thyratron" to such an extent that it becomes conductive, the electron flow being from the negatively charged plates of condenser 16, through resistor 15, to the junction of resistor 15 and the "Thyratron" grid, and thus being in such a direction as to render the "Thyratron" grid more positive.

The "Thyratron" discharge current comes from condenser 21, which discharges through the plate-cathode circuit of the "Thyratron" and igniter 20, igniting the latter.

The second circuit illustrated schematically in Fig. 2 comprises a number of circuit elements like in structure and function to those represented in Fig. 1 and which bear like reference numerals, and similar elements which have like reference numerals primed. It comprises a

source of voltage **10** (100 volts), the negative terminal of which is connected to the grid of a "Thyratron" **14** through a conductor **23** and a resistor **15** (of about 1 megohm). The positive terminal of the source is connected to the plate of the "Thyratron" through a switch **11**, conductors **24** and **25** and a resistor **12'** (approximately 0.5 megohm). An adjustable tap **19** on the source is connected to the "Thyratron" cathode through a conductor **26**. Bridged across the plate and cathode is the igniter circuit, in which igniter **20** is electrically connected in series with a condenser **21** (1 microfarad).

The connection of the negative terminal of source **10** to the "Thyratron" grid, through resistor **15**, causes a fixed but adjustable negative bias to be impressed thereon. The positive terminal of source **10** is connected through switch **11** to a charging circuit comprising resistor **17** (5 megohms) and condenser **16** (1 microfarad), the remote terminal of the latter being connected to the negative terminal of source **10**. Condenser **16** is also provided with a discharge path comprising resistor **15** (1 megohm) and resistor **18'** (10 megohms). It will be noted that the main difference between the Fig. 2 and Fig. 1 embodiments resides in the substitution of resistor **18'** for lamp **18**.

The operation of Fig. 2 circuit will now be described. When the switch **11** is closed, condenser **21** charges through resistor **12'** and igniter **20** to a final voltage approaching that of that portion of source **10** between tap **19** and its positive terminal. The charging current is relatively small, however, and does not ignite the igniter.

The grid initially has a potential, negative with respect to the cathode, determined by the setting of adjustable tap **19** on source **10** and substantially the same as that of the negative terminal of the source with respect to tap **19**. Both plates of condenser **16** initially are at the potential of the negative side of battery **10**. As condenser **16** is charged through resistor **17**, resistors **18'**, **17**, and **15** act as a voltage divider and slowly reduce the negative bias at point **23** as the voltage across condenser **16** increases as a result of charging from source **10**. The circuits are so adjusted that the time constant of condenser charging circuit **10**, **17**, **16**, is short compared to the time constant of condenser discharge circuit **16**, **18'**, **15**. Thus, tube **14** remains nonconductive until condenser **16** becomes charged. Eventually the amount by which the negative grid bias is reduced approximates $\frac{1}{11}$ of the source voltage and the resulting net voltage applied to the input circuit of the "Thyratron" is equal approximately to the algebraic sum of $\frac{1}{11}$ of the source voltage and the voltage between tap **19** and the negative terminal of source **10**. The circuits are so adjusted that the "Thyratron" fires when condenser **16** has become charged. It will be understood that condenser **16** charges at a rate slow with respect to the charging rate of condenser **21**.

The grid potential of tube **14** may be controlled and preset to any desired final value within a reasonable range. By proper setting of adjustable tap **19**, the instant of firing of the "Thyratron" may thus be controlled. When such firing occurs, condenser **21**, which has by this time become sufficiently charged, sends a relatively heavy discharge current through the "Thyratron" and the igniter, igniting the latter. While the voltage across condenser **16** increases by any given amount, the bias of the "Thyratron" grid becomes decreasingly negative by an amount approximately $\frac{1}{11}$ as great as the first-mentioned amount, where resistors and condensers of the values herein suggested are employed.

Both embodiments have in common the feature that the time of ignition of the electrical igniter is dependent on the slow charging of a condenser through a high resistance and its rapid discharge through a partly gaseous path, coupled with the control of the conductivity of that path by another circuit also including a condenser and a resistor. They differ primarily in that the Fig. 1 embodiment depends upon an abrupt reduction of grid bias due to a discharge in a neon lamp to effect firing, while in the Fig. 2 embodiment the grid bias gradually becomes less negative.

While there have been shown and described what are at present considered to be the preferred embodiments of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the true spirit of the invention and it is, accordingly, intended in the appended claims to cover all such changes and modifications as fall within the proper scope of the invention and without that of the prior art.

We claim:

1. A fuze for an ordnance missile comprising, a work circuit including a first capacitor and a squib connected in series, a gaseous discharge device having an anode, a cathode and a control electrode, said anode and said cathode being connected across said work circuit to form a parallel electrical circuit therewith, a source of electrical energy providing positive and negative potentials with respect to said cathode, a first resistor for connecting said source of positive potential to said anode, an input circuit including a second resistor and a second capacitor connected in series, the remaining termination of said second resistor being connected to said source of positive potential and the remaining termination of said second capacitor being connected to said source of negative potential to provide a time varying potential across said second capacitor, means for applying said time varying potential to said control electrode, and means operative on set back upon firing of the missile for initiating the action of said control circuit, whereby upon the expiration of a pre-selected time after set back, said discharge device is rendered conductive thereby causing a surge of current to flow through said squib to produce detonation of said fuze.

2. An arrangement as set forth in claim 1, wherein said means for applying said time varying potential to said control electrode comprises a voltage divider connected across said second capacitor and including a non-linear impedance and a third resistor connected in series, the remaining termination of said third resistor being connected to said source of negative potential, the remaining termination of said non-linear impedance being connected to the junction of said second resistor and said second capacitor, and the junction of said non-linear impedance and said third resistor being connected to said control electrode.

3. An arrangement as set forth in claim 1, wherein said means for applying said time varying potential to said control electrode comprises a voltage divider including a third resistor and a fourth resistor connected in series with the remaining terminations of said third and fourth resistors connected across said second capacitor, and a connection between an intermediate point along said voltage divider and said control electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

2,164,538	Meier	July 4, 1939
2,172,050	Mayberry	Sept. 5, 1939
2,331,317	Germeshausen	Oct. 12, 1943
2,331,771	Germeshausen	Oct. 12, 1943
2,403,567	Wales	July 9, 1946
2,404,553	Wales	July 23, 1946
2,514,434	Windes	July 11, 1950

FOREIGN PATENTS

549,998	Great Britain	Dec. 17, 1942