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S. L. WINDES
ELECTRICAL DETONATOR
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2,514,434

Fig. 1

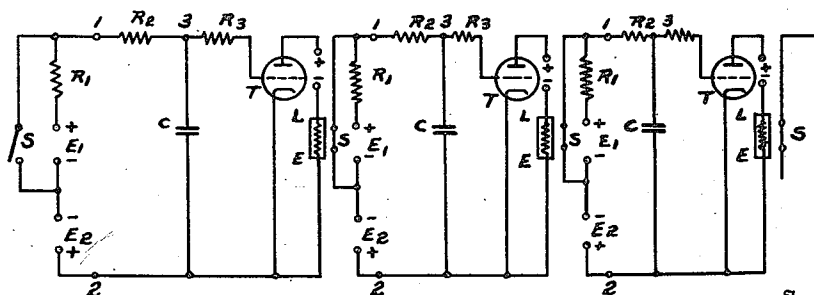
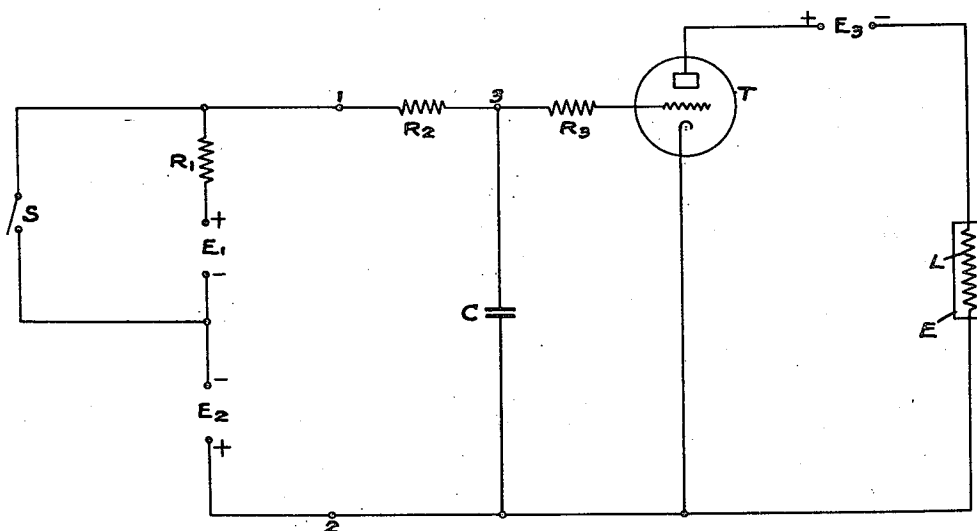


Fig. 2

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ELECTRICAL DETONATOR

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4 Claims. (Cl. 102—70.2)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be made and used by or for the Government of the United States without payment of any royalty thereon.

This invention relates to electrical circuits for introducing a predeterminable time delay between the performance of a given initiating operation, such as the closing of a switch and the final reaction of the circuit, such as the flow of a secondary current or operation of a relay. More specifically, it relates to an ignition circuit for detonating explosives in which a predeterminable time delay may be produced between the closing of a switch and the detonation of the explosive charge.

The field of mining may be mentioned as one of the many fields of application for the invention. In mining operations, for example, it is often desirable to produce blasting effects by the detonation of a plurality of explosive charges. However, in order to minimize the harmful results of percussion which would be particularly great if all charges were detonated simultaneously, it is desirable to introduce a certain amount of time lag between the detonation of successive charges.

It is, accordingly, an object of my invention to provide an electrical circuit capable of producing a time lag of the aforesaid nature.

It is a still further object of my invention to provide an electrical circuit of the aforesaid type which shall be simple and accurate in operation and relatively free of moving mechanical parts and which shall, at the same time, be capable of embodiment in lightweight portable apparatus.

Still further objects and advantages of the invention will become apparent from the following detailed description thereof and from the accompanying drawing which shows two of the many forms in which the principles of the invention may be embodied and in which Fig. 1 is a schematic diagram of an electrical circuit embodying the principles of this invention.

Fig. 2 is a schematic diagram of electrical circuits arranged to provide successive detonations in accordance with the teachings of this invention.

Referring to Fig. 1, the circuit there shown may be considered as being composed of three sections, each with a particular function.

The first section is composed of the sources of voltage E_1 and E_2 , and the resistance R_1 all in series. The shunt connection shown across E_1 and R_1 is arranged so that a voltage of predetermined magnitude and polarity may be suddenly added to the bias voltage E_2 , when the

shunt connection is severed through the opening of switch S, by the detonation of an explosive charge, or by any other means. The explosive may, for example, be any one of the series of charges to be detonated in successively timed relation. In practice the voltages E_1 and E_2 will be supplied by any of the usual sources of voltage but they are preferably unidirectional and connected with the polarities shown in the figure. The voltage E_2 will generally be of sufficient magnitude to bias the tube T to cut-off. The voltage E_1 will generally be of positive polarity, as shown, and greater in magnitude than the voltage E_2 in order that the gaseous tube T may be caused to break down and conduct current when the potential of its grid rises sufficiently, as will be described in greater detail below.

If the initiating voltage applied to the input terminals 1—2 is to be the result of the closing of the switch connection S instead of the opening thereof as previously described, then the polarities of E_1 and E_2 are reversed from those shown in Figure 1. As before, however, the magnitude of the voltage E_1 will exceed that of E_2 . The purpose of the resistance R_1 is to limit the current flow through E_1 and the shunt connection when R_1 and E_1 are shunted by the operation of the switch S.

The second section is composed of a resistance or inductance R_2 , condenser C and the grid-cathode portion of a gaseous discharge tube T, and may, in addition, include resistance R_3 . The elements of this section are arranged so that the potential of the grid of the tube T with respect to the cathode reaches a value at which the tube suddenly breaks down and conducts at a predeterminable time after the initiating voltage of E_1 is applied to the input terminals 1—2 by the circuit already described as section 1. The operation is as follows: Immediately on application of the initiating voltage at the terminals 1—2 the condenser C begins to accumulate a charge derived from the added voltage of source E_1 . The transient current which flows to charge the condenser C passes through the resistance R_2 and hence a continuously decreasing voltage drop will be produced across the resistance R_2 . The polarity of the added voltage is such that the potential at point 3 is lower than that of point 1 as long as current flows. If the condenser were allowed to become fully charged, the charging current would decrease to zero and the potential of the points 1 and 3 would be the same. In practice, the charge, and hence the potential across the condenser C, will

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reach about 63% of its steady state or fully charged value in a time equal to the product of the capacity of condenser C in farads and the resistance of the resistor R₂ in ohms (assuming the resistances in the first section to be negligible compared to the resistance of R₂). As no appreciable grid current flows until the gas in the tube T is ionized, the grid potential will be the same as the potential of the point 2, hence the grid potential rises as the condenser C becomes charged and as the voltage drop across the resistor R₂ decreases. The tube T is so arranged that the tube breaks down; i. e., the gaseous atmosphere of the tube becomes ionized and conduction is initiated at some time during the charging of the condenser C. The resistance R₃ may be provided for the purpose of limiting the grid current to a safe value after the tube has become ionized and conducting, if the other circuit constants have been selected of such values as to be insufficient for this purpose.

It will be understood that the tube T may be of any of the conventional types of gaseous conducting tubes and may have either a hot or a cold cathode. I have found a hot cathode rare gas tube such as the RCA No. 884 or 885 to be satisfactory, although one of the usual thyratron tubes, employing mercury vapor may be used. Of the cold cathode tubes, the RCA No. OA4G rare gas tube is satisfactory. It will also be understood that a vacuum type tube may be used in certain cases, although the characteristics of the gaseous tubes are preferable because the anode current of tubes of that type rises suddenly from substantially zero to very high values instantaneously when breakdown occurs. Further, they are capable of handling much higher anode currents at lower voltages.

The third section is composed of the voltage source E₃, electrical load L, preferably a resistance, and the plate-cathode portion of the tube T. This section performs the function of detonating the explosive E either directly through the heating effect of the load L or through a relay which may be controlled by the load L.

The operation of the entire circuit will be readily apparent. When the grid potential of the tube T reaches the critical breakdown voltage after a time delay determined by the product CR₂ as already described, the gas in the tube will ionize and anode current will flow through the load L. The voltage E₃ will be the source of this anode current. In practice the explosive charge E may be an electric blasting cap or other detonating agent. The timing may be varied at will by varying the values of either R₂ or C, in any desired manner, as by use of variable elements, substituted elements of different values, or switching in of additional elements.

It will be understood that the potential source applied between the points 1 and 2 may be of any form, although it is preferably unidirectional. For example, it may be a battery or a condenser charged by an external source and then applied by suitable switching arrangement to the points 1 and 2. Similarly, the voltage source E₃ may be a battery or a precharged condenser so long as it is capable of carrying a sufficient electrical charge to ignite the detonating agent. The use of condensers of this nature will operate to lighten the weight of the apparatus. Since the power requirements of the circuit comprising condenser C and resistor R₂ can be very small, those elements may be of the high precision type. Since the anode circuit is independent of the

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grid circuit except for the control or trigger action of the grid, it can be designed to handle the heavy currents necessary to detonate the explosive charge without interfering with the precision of the timing circuit.

Furthermore, it will be apparent that in the disclosed form, the tube T acts as a relay for closing the igniting circuit E₁L, the tube T in stand-by condition being supplied with whatever potentials its characteristics require to prevent flow of current in the igniting circuit, and that in this connection the "first section" above described is a potential altering means and the "second section" a time-delay network, whereby a controlling potential of the relay T may be changed, with predetermined time delay, to cause relay T to close the igniting circuit, this being accomplished, in the embodiment shown, by the establishment of an electron stream from cathode to anode tube T. For example, if tube T is of such structure as to require negative grid bias to prevent flow of current from anode to cathode, the source E₂ will be employed to supply this stand-by bias; if tube T is at cut-off with a positive bias, no potential source E₂ will be required; if tube T is operative to pass anode current at all times except when supplied with a high negative bias, the tube may be rendered operative simply by decreasing the negative bias supplied from E₂ in any suitable manner, although the use of a bucking potential E₁ is preferred.

Moreover, while I have shown the invention as applied to detonation of successive explosive charges in mine blasting operations, it will be understood that it may be used in any field of application wherein it is desired to introduce a given time lag between the closing of a switch and the detonation of the explosive, regardless of whether the explosive charge is single or multiple. For example, it might conceivably be used for the detonation of bombs or shells after a predetermined time interval.

It also will be understood that many modifications in the circuit details and configurations may be made by those skilled in the art to which the invention appertains without departing from the true spirit and scope of my invention. All such modifications I aim to include within the scope of the appended claims.

Having described my invention in accordance with the patent statutes of the United States, what I claim is:

1. An electrical detonator comprising an explosive charge and a circuit for igniting said charge at a predetermined time, said circuit comprising a gaseous discharge tube, means for supplying energizing potential to said tube, a closed resistance-capacitance circuit for initiating the breakdown of said tube at a predetermined time, an electrical source in said circuit of potential and polarity operative to break down the tube, a second closed circuit including an electrical source connected to the tube in a relation to inhibit breakdown of the tube by the first-named closed circuit, means to open the inhibiting circuit, and means for detonating the explosive in response to the breakdown of said tube.

2. In an electrical detonator, a gaseous electronic discharge device including an anode, cathode, and control grid, a detonating device and a source of potential connected in series between said cathode and anode, a condenser, a first resistor connected to said grid and in series with said condenser and said cathode, a

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second resistor, two sources of potential of unequal magnitude connected in opposed relation and in series with at least said second resistor between said cathode and the junction of said condenser and said first resistor, the polarity of the greater of said sources being such as to tend to initiate conduction through said discharge device and the polarity of the lesser of said sources being such as to tend to inhibit conduction through said discharge device, a normally closed switch connected in series with said second resistor across the greater of said two opposed sources of potential whereby when said switch is opened said electronic discharge device conducts after a predetermined delay and said detonating device is fired.

3. In combination, a first and second electrical detonator, each including a gaseous electronic discharge device including an anode, cathode and control grid, a detonating device and a source of potential connected in series between said cathode and anode, a condenser, a first resistor connected to said grid and in series with said condenser and said cathode, a second resistor, two sources of potential of unequal magnitude connected with their polarities in opposed relation and in series with at least said second resistor between said cathode and the junction of said condenser and said first resistor, the polarity of the greater of said sources being such as to tend to initiate conduction through said discharge device and the polarity of the lesser of said sources being such as to tend to inhibit conduction through said discharge device, the first detonator having a normally closed switch connected in shunt with its second resistor and the greater of its two opposed sources of potential, whereby when said switch is opened said electronic discharge device conducts after a predetermined delay and said detonating device is fired, said second detonator having a normally closed con-

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necting link in shunt with its second resistor and the greater of its two opposed sources of potential, said connecting link being in close proximity to the detonating device of said first detonator whereby firing of said first detonating device will break said connecting link and cause firing of said second detonating device.

4. In combination, an electrical discharge device having an anode, cathode, and control grid, a resistor, first and second sources of potential connected to their polarities in opposed series relation and in series with at least said resistor across said control grid and cathode, a condenser also connected between said control grid and cathode, a third source of potential and a detonating device connected in series between said anode and cathode, another resistor, and a switch, said first source of potential being of greater magnitude than said second source and being connected in series with said other resistor, said switch being connected in shunt relation to said first source of potential connected in series with said other resistor, operation of said switch being effective to cause said discharge device to conduct after a predetermined delay and fire said detonating device.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,552,321	Lea	Sept. 1, 1925
1,711,693	Ruhlemann	May 7, 1929
1,776,796	Ruhlemann	Sept. 30, 1930
1,795,972	Ruhlemann	Mar. 10, 1931
1,807,708	Ruhlemann	June 2, 1931
1,938,742	Demarest	Dec. 12, 1933

Certificate of Correction

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STEPHEN L. WINDES

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 11, for the words "connected to" read *connected with*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of November, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.