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DELAY TIMER

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FIG. 1.

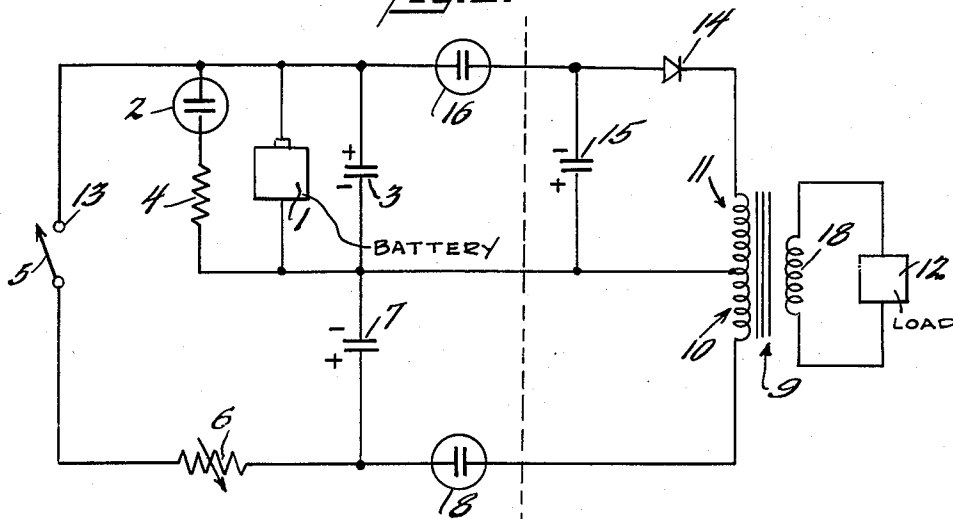
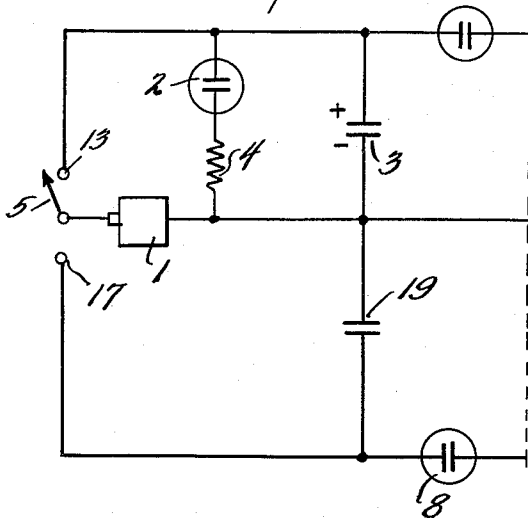


FIG. 2.



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DELAY TIMER

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6 Claims. (Cl. 328—78)

This invention relates to time delay circuits.

In general, a time delay circuit according to this invention comprises a source of steady state or constant electrical potential, preferably a nuclear battery, combined with a first stage timer interval determining circuit feeding into a second stage time interval determining circuit which also serves as a triggering circuit to discharge stored energy into the load at the end of the desired time interval.

The first stage time interval determining circuit may be varied in form, as hereafter described, depending on the total time interval desired.

The time delay circuits provided by the invention are characterized by high energy output and a wide range of time intervals ranging from near zero seconds up to several hours or more.

Further advantages provided are that the conservation of energy in the circuits is very high, and a relatively large energy pulse is delivered to the load compared to the power output of the nuclear battery employed. The nuclear battery assures long shelf and use life, and the timer is free from the influence of temperature and pressure changes over wide ranges, as well as from influence by large mechanical accelerations and from mechanical fatigue. A further important advantage is that the time interval has high reproduceability with the circuits according to the invention.

In general terms a delay circuit according to this invention operates by first accumulating electrical energy in one part of an electrical circuit prior to the beginning of the desired time interval. Then at the beginning of the desired time delay interval an electric current is allowed to flow into a two-stage sequentially operating timing circuit so that at the end of the desired time interval sufficient potential will have developed to trigger the circuit so that the energy stored before the beginning of the time interval will be transferred to the load in a pulse to accomplish the needed action in the load.

One particular form of the time delay circuit as illustrated by Figure 1 utilizes the steady state or constant potential source circuit simultaneously as the energy storage circuit and the power circuit for supplying the electric current required to actuate the two-stage timing and the triggering circuits. This form of the invention is particularly well suited for the 0 to 30 minute range of delay.

Another form of the time delay circuit as illustrated by Figure 2 isolates the nuclear battery from the constant potential or stored energy circuit at the beginning of the time interval and connects it to the two-stage timing and triggering circuits. This form of the invention is well suited for delay intervals in the range of one-half hour up.

In both forms of the invention the two-stage time delay circuit builds up an electrical potential in the triggering circuit at the end of the desired time delay interval to discharge a gas discharge diode which served up to the time of discharge to isolate the stored energy circuit from the load. The different embodiments result from convenience

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and economical use of components rather than from any fundamental electrical circuit limitations.

In the circuit according to Figure 1, the battery 1 is a constant current nuclear battery having a relatively high equilibrium voltage, that is, in the neighborhood of 10,000 v. The rated voltages for discharge diode 2 and capacitor 3 are well below the equilibrium voltage of the nuclear battery 1.

The steady state or constant potential circuit consists of nuclear battery 1, discharge diode 2, capacitor 3 and resistance 4, connected as shown in Figure 1.

Switch arm 5 and contact 13 are the switching means to initiate the timing interval.

The first state time interval determining circuit consists of switch arm 5, contact point 13, resistor 6, capacitor 7, gas discharge diode 8, and the part 10 of the primary of the transformer 9 connected as shown in Figure 1.

Resistance 6 is either continuously variable over a wide range of values or it can be a preselected value at any value over a wide range of resistance depending on the desired time interval for the operation of the first stage time interval determining circuit. Capacitor 7 has a capacitance dependent on the time interval desired. Discharge diode 8 has a discharge potential of the same order of magnitude as the rated maximum operating voltage for capacitor 7. The transformer 9 has a tapped primary, dividing the primary into two parts 10 and 11. The secondary 18 of transformer 9 is connected to the load 12.

The second stage circuit consists of capacitors 3 and 15, diodes 16 and 14, and part 11 of the primary of transformer 9. The rectifier 14 is a dry rectifier of which a silicon diode is an example. Capacitor 15 and gas discharge diode 16 have voltage ratings of the same order of magnitude as capacitor 3, although in a specific circuit they will not be equal, depending on the selection of the other components in the circuit and the desired time interval.

A specific example of the form of the invention shown in Figure 1 has component values and operates as follows:

The circuit requires the maintenance before the beginning of the desired time interval of a steady state or constant potential of 390 volts across the .07 microfarad 500 volts rated capacitor 3 with the polarity shown. This potential is built upon capacitor 3 by the nuclear constant current battery having a current rating of 100 micromicroamperes and an equilibrium voltage in the 5000 to 10,000 voltage range. The potential is maintained at 390 volts by the discharge diode 2 of this rated discharge voltage through the relatively high resistance 4 which has a value of 100 megohms. The flow of current through the resistance 4 is slow enough to prevent the rapid discharge of capacitor 3 which would take place otherwise. As the current flows through the series circuit 3, 2, 4, the diode 2 becomes non-conducting as soon as the voltage across 3 is reduced below its critical limits. Thus capacitor 3 is maintained at approximately 390 volts $\pm 2\%$ or closer, depending on the selection of diode 2.

At the beginning of the desired time interval, switch arm 5 is connected with switch point 13. The part of the charge on capacitor 3 is delivered to the .002 microfarad capacitor 7 at a rate determined by the value of resistance 6 which has a maximum value of 530 megohms. When capacitor 7 is charged sufficiently to raise its voltage to 230 volts which is the discharge rating of diode 8, then capacitor 7 will discharge through the series circuit consisting of capacitor 7, diode 8 and the part of the transformer primary identified as 10. This series circuit is a circuit containing inductance in the form of the primary winding 10, capacitance in the form of a capacitor 7 and a relatively low resistance from the connections and the discharged diode. These are the requirements for an oscillating electrical circuit. Thus an alternating current

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pulse of decreasing amplitude will pass through winding 10. This in turn will induce an alternating potential across the terminals of winding 11. Then in the series circuit made up of winding 11, the silicon rectifier 14 and the 250 micromicrofarad capacitor 15 a half-wave rectified current will flow charging capacitor 15 with the polarity shown. The inverse resistance of the silicon diode 14 will maintain the charge on the capacitor 15 when the polarity is as shown. The time rate of charge of capacitor 15 will depend on its capacitance as well as the characteristics of the alternating current passing through winding 10 of the transformer 9.

Diode 16 having a discharge rating of 440 volts is in a series circuit with capacitors 3 and 15. The polarities of 3 and 15 are such that they add. Capacitor 3 has decreased about 30 to 40 volts to approximately 350-360 volts. Thus a voltage built up of something over 100 volts on capacitor 15 will result in in the 440 volt discharge limit of diode 16 being exceeded. With the diode 16 in the discharge or low resistance state capacitor 3 has the correct polarity to pass through the rectifier diode 14 and coil 11 to complete the series circuit. The relatively large pulse of current through winding 11 will induce a potential in secondary 18 of transformer 9. Although capacitor 15 is in series opposition to capacitor 3 the higher voltage and the appreciably larger capacitance of capacitor 3 prevent capacitor 15 from bypassing any appreciable quantity of current as it passes from capacitor 3 to the load.

The components enumerated in the specific example result in a circuit with a time delay interval of 1.0 sec. $\pm 5\%$. The energy output is relatively large and is approximately 35,000 ergs.

A circuit particularly well suited for the one second to several hour time interval range is illustrated in Figure 2.

The steady state or constant potential energy storing circuit is basically similar to the corresponding circuit of Figure 1 and consists of nuclear battery 1, discharge diode 2, capacitor 3, resistance 4, switch arm 5 and switch point 13. For convenience in drawing the whole circuit of Figure 2, the component positions are different from Figure 1. However, this part of the two circuits is electrically equivalent. The actual values of the components may be the same or different depending on the selection of the other variables determining the total time delay interval.

The first stage time interval determining part of the circuit for the one-half to several hour range timer as shown in Figure 2 consists of nuclear battery 1, switch arm 5, contact point 17, capacitor 19 and discharge diode 8, and part 10 of the primary of transformer 9.

The second stage parts of the circuit of Figure 2 are the same as Figure 1 except as selected time intervals may necessitate a different selection of the sizes of the components.

A specific example of the form of the invention shown in Figure 2 has component values and operates as follows:

The steady state or constant potential source circuit consists of nuclear battery 1, resistor 4, diode 2 and capacitor 3 and is entirely equivalent to the corresponding circuit in Figure 1 when switch arm 5 is connected to contact point 13. Switch arm 5 is maintained connected to contact 13 prior to the initiation of the timing circuit, in order to keep the capacitor fully charged.

At the beginning of the desired time delay interval the nuclear battery 1 is removed from the constant potential circuit by moving switch arm 5 from contact point 13

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to contact point 17. The isolated constant potential circuit retains its stored charge for subsequent discharge into the load. The 720 micromicrofarad capacitor 19, the 100 micromicroampere nuclear battery, switch arm 5 and contact point 17 constitute a series circuit. Since battery 1 is a constant current source with an equilibrium voltage in the 5,000 to 10,000 volt range, capacitor 19 will receive charge at an essentially constant rate and its voltage will increase linearly with time until the voltage exceeds 230 volts, the discharge voltage of diode 8. With the components enumerated this time will be approximately 30 minutes.

After capacitor 19 is raised to a potential sufficiently high to discharge diode 8 namely 230 volts capacitor 19 will discharge through winding 10 of transformer 9. From here on the action leading up to triggering capacitor 3 and its release of energy into the load will be identical to the sequence explained for the circuit of Figure 1.

The components enumerated in this specific example result in a circuit with a time delay interval of 30 minutes $\pm 3\%$. The energy output is relatively large and is approximately 35,000 ergs.

I claim:

1. A delay timing circuit comprising a constant potential circuit having a first capacitor maintained at a substantially constant voltage, a second capacitor connected to said constant potential circuit, a first diode and an inductance winding connected in series with said second capacitor to provide an alternating current in said winding upon discharge of said second capacitor, means for charging said second capacitor to the discharge voltage of said first diode, a rectifier and a third capacitor connected in series with said inductance winding, said first and third capacitors being connected in series opposition through a second diode, and said first capacitor being connected in series with said inductance winding through said second diode and said rectifier, and a load inductively coupled to said inductance winding.

2. A delay timing circuit as claimed in claim 1 wherein the voltage and capacity of said first capacitor exceeds that of said third capacitor.

3. A delay timing circuit as claimed in claim 2 wherein said constant potential circuit comprises a nuclear battery in series with said first capacitor, and switch means for disconnecting said battery from said first capacitor and placing it in series connection with said second capacitor.

4. A delay timing circuit comprising a constant potential circuit comprising a nuclear battery for maintaining a substantially constant voltage of a first capacitor, a means for initiating the time delay circuit operable to connect said first capacitor in series with a first resistance and a second capacitor, a first diode and an inductance winding connected in series with said second capacitor to provide an alternating current in said winding upon discharge of said second capacitor through said first diode, a rectifier and a third capacitor connected in series with said inductance winding, said first and third capacitors being connected in series opposition through a second diode, and said first capacitor being connected in series with said inductance winding through said second diode and said rectifier, and a load inductively coupled with said inductance winding.

5. A delay timing circuit as claimed in claim 4, wherein the voltage and capacity of said first capacitor exceeds that of said third capacitor.

6. A delay timing circuit as claimed in claim 5 in which said first resistance is a variable one.

No references cited.