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Mercier

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[54] **RELAY TIMING SYSTEM**

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[52] **U.S. Cl.**.....**307/141,** 307/117, 340/227 R

[51] **Int. Cl.**.....**H01h 37/00**

[58] **Field of Search** 317/132; 307/141, 117; 340/227

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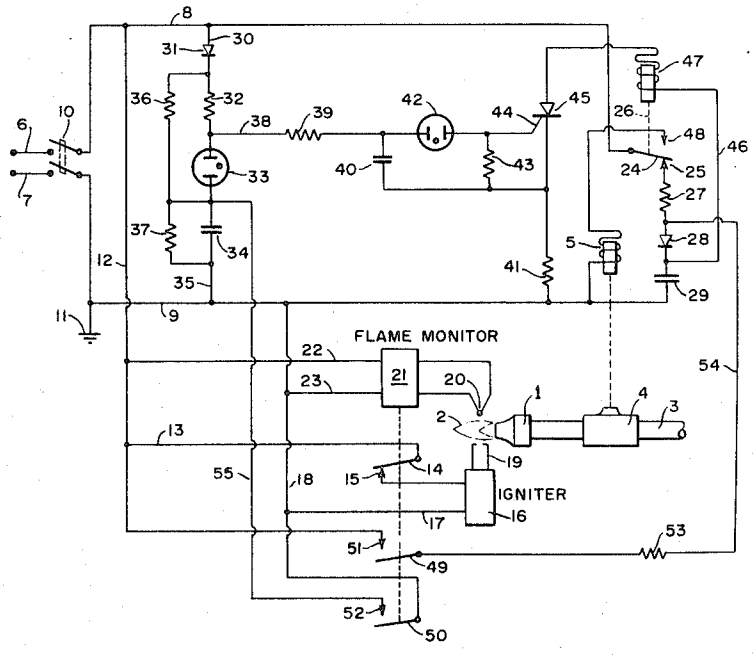
Primary Examiner—Robert K. Schaefer
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[57] **ABSTRACT**

A timing system having a pair of conductors connected to an alternating voltage source through a switch. The system includes a first charging circuit across the pair of conductors consisting of a first condenser, a diode and an impedance whereby the condenser charges at a given rate. A second charging circuit across the pair of conductors, consisting of a rectifier, a trigger tube and a second condenser and current limiting resistance, acts as a timing circuit. The second condenser receives incremental charges and after a predetermined delay charges above a predetermined minimum value. A third charging circuit is connected across the trigger tube and second condenser and includes a resistance and a third condenser, with a second trigger tube and a resistance across the third condenser. When the second condenser reaches the above predetermined minimum value, the voltage on the third condenser fires the second trigger tube and generates a voltage pulse across its resistance which is supplied to the igniting electrode of a silicon control rectifier which conducts to discharge the first condenser through the operating coil of a relay. The discharge current from the first condenser rises above the pull-in value for the relay and remains above the hold-in value for the relay for a predetermined time after which it drops below such hold-in value. The relay is shown controlling the solenoid valve for a gas burner system.

The gas burner system is provided with flame igniter and flame monitoring means. The flame monitoring means is provided with switches which cause the relay to remain closed in the presence of the flame, to remain in an open state upon failure of the flame to ignite and to recycle the system once upon a subsequent flame failure. The entire system can be recycled by opening the switch to the voltage source and then reclosing it.

8 Claims, 2 Drawing Figures



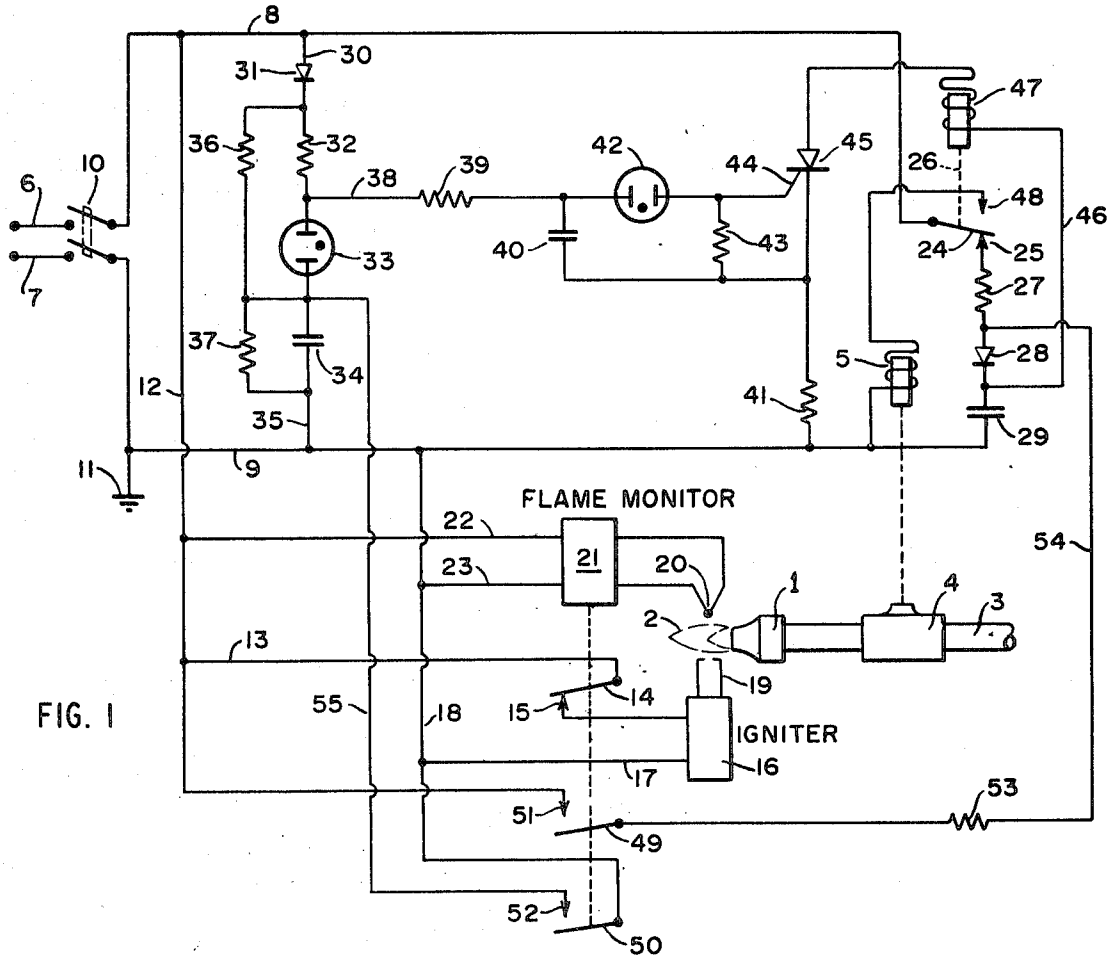


FIG. 1

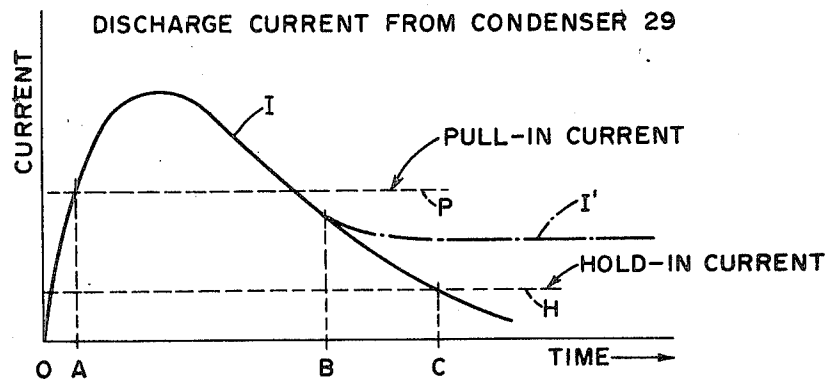


FIG. 2

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RELAY TIMING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

Relay Timing System.

2. Description of the Prior Art

A requirement has existed for a timing circuit which, after an initial preset delay, will energize a relay which remains closed for another predetermined time, after which it remains open until the circuit is de-energized and then re-energized. An example of a system which such a requirement exists is one which controls the ignition nd monitoring of a gas burner. The initial time delay is to permit a flame igniter to be properly energized before the energization of the relay opens a valve to supply gas to the burner. The second delay is to permit the burner flame to be established and to be detected by a flame monitor which will take over control of the valve, in absense of which the de-energization of the relay will reclose the valve and keep it closed until the operator elects to restart the cycle. Previous attempts to satisfy such requirements have been unduly complex and expensive, have lacked a sufficient degree of flexibility and have been deficient in their fail-safe properties.

The present invention eliminates the deficiences of the prior art in a simple, inexpensive and completely fail-proof manner.

SUMMARY OF THE INVENTION

In the present invention a main control switch connects the system to a source of voltage, such as an alternating voltage. Upon closure of such switch a first condenser is connected into a charging circuit, which may include a rectifier in the case of an alternating voltage source and an impedance so that the voltage in the condenser rises above a predetermined minimum after a first time delay. The condenser is then discharged, by means of an ignition controlled switch through an impedance and the operating member of a relay. The time constant of the discharge circuit is such that the discharge current first rises above the pull-in value for the relay and then after a second time delay, decays below the hold-in value for the relay. A timing circuit first supplies an ignition impulse to the ignition controlled switch after a predetermined third delay in excess of the first delay. That timing circuit includes a trigger circuit supplying increments of charge to a second condenser to raise its voltage to a predetermined firing value in said third delay period. Another circuit, including a trigger device and a third condenser, is triggered, when the second condenser reaches its firing value, and generates the ignition pulse for the ignition controlled switch. Other aspects of the invention include a controlled device set in operation by the relay with a detecting device to detect whether or not the device starts to operate and whether thereafter it fails to operate. Such other aspects include; causing the system to go into a stable condition with the relay de-energized when the device fails to operate; causing the system to recycle once on any subsequent failure of the device to continue to operate. The system can be completely recycled only by opening and reclosing the main control switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram illustrating the application of this invention to a flame control system.

FIG. 2 is a graph showing a characteristic discharge curve for a relay activating condenser.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 the invention is shown, by way of example, as being applied to a gas burner control system comprising a burner 1 adapted to support a flame 2. The burner is supplied with a combustible gas from a supply line 3 through a solenoid valve 4 actuated by a solenoid 5 which, when supplied with energizing current, opens valve 4 and which, when the energizing current stops, closes valve 4. The system is supplied with current from a source of alternating current through a pair of power lines 6 and 7 which are adapted to be connected to a pair of leads 8 and 9 through a suitable starting switch 10. Lead 9 may be grounded at 11. Conductors 12 and 13 extend from lead 8 through a switch arm 14 which engages a normally closed contact 15 which is connected to one side of an igniter unit 16, the other side of which is connected by conductors 17 and 18 to ground lead 9. Thus when switch 10 is closed, igniter 16 is energized and starts to heat its ignition element 19 to ignition temperature. In order to be sure that element 19 is at the proper ignition temperature before gas is supplied to burner 1, it is necessary to delay energization of solenoid 5 for a predetermined time after switch 10 is closed. This is one of the functions performed by the present invention as will be described below. After such an appropriate delay, solenoid 5 is energized, opening solenoid valve 4 and thus allowing gas to flow from supply line 3 to burner 1 where the flame 2 is ignited by the ignition element 19. The presence of such a flame is detected by a suitable device such as a thermocouple 20 which, when heated by flame 2 supplies a voltage to a flame monitor unit 21, of any well known type, which will actuate switch arm 14 to disconnect such arm from contact 15 thus de-energizing the igniter unit 16. Flame monitor 21 derives its power from a pair of leads 22 and 23 connected respectively to conductors 12 and 18.

In order to introduce the desired delay in the energization of solenoid 5, as well as to accomplish several other functions, the novel system as shown above lead 9 is used. In this system, lead 8 is connected to a switch arm 24 which engages normally closed contact 25 of a relay 26. Contact 25 is connected through a resistance 27 (e.g., 47KΩ), a diode rectifier 28 and a condenser 29 (e.g., 200 μf) to ground lead 9. From lead 8 there also extends a circuit comprising a lead 30, a diode rectifier 31, a resistance 32 (e.g., 2.7 megohms), a glow discharge or trigger tube 33, such as a neon lamp which fires when a predetermined voltage (e.g., 65–95 volts) appears across its terminals, a condenser 34 (e.g., 20 μf), and a lead 35 to ground lead 9. Leakage resistances 36 (e.g., 22 megohms) and 37 (e.g., 22 megohms) are connected respectively across tube 33 and condenser 34. From the junction between resistance 32 and tube 33, a lead 38 extends through a resistance 39 (e.g., 2.7 megohms), a condenser 40 (e.g., 0.05 μf) which is small in comparison with condenser

34, and a relatively small resistance 41 e.g., 18 KΩ). A second glow discharge or trigger tube 42, similar to tube 32, is connected in series with a relatively small resistance 43 (e.g., 1 KΩ) across condenser 40, so that when tube 42 fires it will rapidly discharge condenser 40 thus producing a voltage pulse across resistance 43.

The voltage pulse across resistance 43 is supplied to the ignition electrode 44 of a silicon control rectifier 45. From the junction of rectifier 28 and condenser 29 is connected a circuit consisting of a conductor 46 in series with the operating solenoid 47 of relay 26, the silicon control rectifier 45, and the resistance 41.

The operation of the above system is as follows. When switch 10 is closed a charging circuit for condenser 29 is completed through lead 8, switch arm 24, contact 25, resistance 27, diode 28, condenser 29 and lead 9. Thereupon condenser 29 starts to charge exponentially toward the peak value of the alternating voltage on lines 6 and 7. At the same time the voltage between lines 8 and 9 is impressed on the series circuit consisting of lead 30, diode 31 resistance 32, tube 33 and condenser 34. Condenser 34 will have been completely discharged, either through resistance 37, or otherwise as will be described below. Therefore, relatively early in the first positive half cycle on lead 8, tube 33 will fire and deliver a pulse of charging current through diode 31 and resistance 32 to condenser 34. When tube 33 fires, the voltage across it will drop to a lower value (e.g., 35–40 V). The relatively high value of resistance 32 limits such pulse to such a small value that the charge on condenser 34 increases by a small incremental value, the major portion of the voltage drops from lead 8 to lead 9 occurring across resistance 32. During the same positive half cycle, condenser 40 starts to charge through diode 30, resistance 32, lead 38 and resistances 39 and 41. However, due to the high time constant of this circuit, the voltage on condenser 40 rises at a sufficiently low rate so that by the time tube 33 fires, the voltage across condenser 40 is insufficient to cause tube 42 to fire. As soon as tube 33 fires, any excess of voltage across condenser 40 over the voltage across condenser 34 is discharged through tube 33 into condenser 34.

During subsequent positive half cycles on lead 8, additional increments of charge are delivered to condenser 34 which, in effect, back biases tube 33 and causes it to fire at higher and higher values of voltage on lead 8. As condenser 34 charges to such higher values, the charge on condenser 40 also rises until it reaches a value sufficient to cause tube 42 to fire and discharge condenser 40 through resistance 43. The resultant voltage impulse impressed on ignition electrode 44 causes silicon control rectifier 45 to fire. Sometime before rectifier 45 fires, condenser 29 will have become charged above a predetermined minimum value, to be explained below. When rectifier 45 fires, condenser 29 will discharge through the circuit consisting of conductor 46, operating solenoid 47 of relay 26, silicon control rectifier 45 and resistance 41. In FIG. 2 there is shown a typical curve I for the current in such a discharge circuit. In FIG. 2 time is plotted along the horizontal axis and current magnitude is plotted along the vertical axis. The value of current through solenoid 47 sufficient to cause solenoid 47 to operate relay 26 is its "pull-in" value shown at level P in FIG. 2, while the value of such current above which solenoid 47 will continue to operate relay 26 but below which it will cease to operate is its "hold-in" value shown at level H. If silicon rectifier 45 fires at time O, within a very short interval current I will rise above the "pull-in" value and solenoid 47 will operate relay 26 to move switch arm 24 away from contact 25 into engagement with a normally open contact 48. Current I will not rise above such pull-in value unless condenser 29 has been charged above the predetermined minimum value referred to above. The charging circuit for the condenser 29 has a predetermined time constant such that the delay between the closing of the switch 10 and the reaching of said predetermined value is substantially shorter than the delay from the closing of switch 10 to the firing of rectifier 45. The closure of switch arm 24 on contact 48 closes a circuit from lead 8 through switch arm 24, contact 48 and solenoid 5 to lead 9, whereupon solenoid 5 is energized to open value 4 and admit gas to burner 1. The delay between the closing of the switch 10 and the opening of valve 4 is of such a predetermined value to allow ignition element 19 to reach full normal ignition temperature, and may be, for example, of the order of 30 to 50 seconds. This time delay is predetermined primarily by the values of condenser 34 and resistance 32.

If the igniter element 19 ignites flame 2, the flame will be detected by the thermocouple 20 and the flame monitor 21, which in addition to disconnecting switch arm 14 from contact 15, also operates a pair of switch arms 49 and 50 to close them respectively on contacts 51 and 52. Switch arm 49 is connected through resistance 53 (e.g., 10 KΩ) and lead 54 to the junction between resistance 27 and diode 28, while contact 51 is connected through conductor 12 to lead 8. As a result a circuit is established extending from lead 8, through conductor 12, contact 51, switch arm 49, resistance 53, lead 54, diode 28 and condenser 29 to lead 9. This circuit keeps the charge on condenser 29 sufficiently high so that its discharge current will follow curve I^1 in FIG. 2 and remain above the "hold-in" value of solenoid 47. Such value of current is also sufficient to keep silicon control rectifier 45 conducting without the necessity of supplying igniting impulses to ignition electrode 44. Switch arm 50 is connected to lead 18 and contact 52 is connected by lead 55 to the junction between tube 33 and condenser 34. Thus closure of arm 50 and contact 52 established a discharge circuit directly across condenser 34 and immediately completely discharges condenser 34. The removal of the voltage on condenser 34 also causes the voltage on condenser 40 to be reduced to a value well below that necessary to cause tube 42 to fire. Therefore the igniting impulses to ignition electrode 44 stop.

If, for any reason flame 2 is not established within a predetermined delay from time A to time C in FIG. 2 (e.g., about 10 seconds) after opening of value 4, the switches associated with flame monitor 21 remain in their initial portions. Therefore condenser 29 is not supplied with additional charging current and continues to discharge through solenoid 47 along the solid line curve I in FIG. 2 so that at time C the current through solenoid 47 will drop below its "hold-in" value H and solenoid 47 will drop relay 26 to move switch arm 24 from contact 48 to contact 25. This opens the

circuit to solenoid 5 which de-energizes and closes valve 4 to shut-off the flow of gas to burner 1.

It will be noted that if flame 2 is not ignited, flame monitor 21 will not close switch arm 50 on contact 52 so that the charge on condenser 34 will not be removed. Therefore the voltage level at which tube 33 continues to fire on each positive half cycle on lead 8 is sufficiently high to cause condenser 40 to attain a sufficiently high charge in each such half cycle to fire tube 42 and to continue to supply an igniting pulse to ignition electrode 45. Although during such positive half cycle prior to tube 42 firing, condenser 29 will receive some charge through the circuit including switch arm 24 and contact, the time constant time its charging circuit is sufficiently high so that the voltage, which it reaches when silicon control rectifier is ignited by its ignition electrode 44, limits the discharge current from condenser 29 to well below the predetermined minimum value, discussed above, required to generate the "pull-in" value P. Therefore, condenser 29 will continue to be discharged during each such cycle and its charge is not permitted to rise to a value great enough to supply a "pull-in" current to solenoid 47. Therefore relay 26 will continue to maintain switch arm 25 disengaged from contact 48 and solenoid value 4 will remain closed.

In order to recycle the system it is necessary to remove all power from the system by opening switch 10 to permit the charge on condenser 34 to leak off through resistance 37. When switch 10 is reclosed the system will recycle.

Once the flame monitor 21 detects the presence of a flame 2 and the system continues to operate as previously described, it is desirable that a temporary flame-out should not require the intervention of the operator to open switch 10 but rather to have the system automatically make one trial to restart the flame before it goes into its stable shut-down condition. The provision of switch arm 50 and contact 52 on flame monitor 21 gives this desirable result. When flame monitor 21 operates to close switch arm 50 on contact 52, a virtual short-circuit is created across condenser 34 and condenser 34 and therefore its charge is held at zero. Also, as previously described, the igniting pulses supplied to silicon control rectifier cease. Thereafter if flame 2 goes out, flame monitor 21 will drop its switch arms 15, 49 and 50. Opening of the switch arm 49 — contact 51 path will remove the charge maintaining circuit for condenser 29 which will thereupon resume its discharge curve I of FIG. 2 until, after a very short interval, its discharge current through solenoid 47 drops below the "hold-in" value H and relay 26 is de-energized to

de-energize solenoid 5 and close its associated value 4. The removal of switch arm 50 from contact 52 permits condenser 34 to start recharging immediately. At the same time closing of switch arm 14 on contact 15 starts the reheating of igniter element 19. It will be noted that when flame monitor drops its associated switch arms, the entire system is restored to the same conditions as existed when the switch 10 was initially closed. Therefore, without opening and reclosing switch 10, the system recycles once to try to re-establish flame 2. Failure to re-establish such flame will cause the system to pass into its stable shut-down condition as described above. Thereafter the intervention of the operator to open and reclose switch 10 is required to restart the system.

While the timing system described above has special novel aspects when applied to a gas burner system, it can be used whenever the particular sequence of time delays which the system produces are required. Such a generally applicable system might be produced by disconnecting leads 12, 55 and 54 and permitting solenoid 5 to operate any type of device in which the timing cycle afforded by the system of this invention may be useful.

Various charges may be made in the details described provided they are within the scope of its appended claims. For example instead of a silicon control rectifier, any circuit closing device, for example a thyratron, which may be triggered into operation as long as current above a predetermined value may be used. Trigger devices other than neon glow tubes would be useful. The values of the circuit elements could be subject to wide variations so as to produce virtually any desired time delay periods. Various other variations and equivalents will suggest themselves to those skilled in the art.

What is claimed is:

1. A timing system comprising:
   a. a pair of conductors;
   b. first switch means for connecting said conductors to a voltage source;
   c. a first condenser;
   d. a charging circuit for said condenser connected to said conductors, said charging circuit having a time constant of a value to cause the charge on said condenser to rise above a predetermined minimum value after a first time delay following the operation of said first switch means;
   e. a discharge circuit having a predetermined discharge impedance and comprising said condenser, the operating member of a relay, and a second switch adapted to close in response to a voltage impulse;
   f. timing means responsive to the operation of said first switch means for generating such voltage impulse after a second time delay in excess of said first time delay;
   g. said discharge impedance being sufficiently low to cause the discharge current from said condenser, so charged above said minimum value, to rise above the pull-in value of said relay, and the time constant of said discharge circuit being sufficiently high to cause said discharge current to remain above the hold-in value for a third time delay and to drop below said hold-in value after said third time delay.

2. A system as in claim 1 in which said voltage source is an alternating voltage source and in which said timing means comprises:
   a. a second condenser;
   b. charging means for delivering a pulse of charging current to said second condenser during each alternate half cycle of said alternating voltage and for limiting the value of said pulse to a limited value which will produce an incremental rise in the charge on said second condenser; and

c. pulse producing means, responsive to said second condenser being charged to a predetermined value substantially in excess of any such incremental rise, for generating said voltage impulse.

3. A system as in claim 2 in which charging means comprises:

a. a series circuit connected between said conductors and including a half-wave rectifier, an impedance, a trigger device adopted to conduct current when the voltage across it rises above a predetermined value, and said second condenser;

b. said last named impedance being sufficiently high to limit the value of said pulse of charging current to said limited value.

4. A system as in claim 3 in which said pulse producing means comprises:

a. a circuit connected across said second condenser and comprising said trigger device, and impedance and a third condenser; and

b. a circuit connected across said third condenser comprising a second trigger device adapted to conduct current when the voltage across it rises above a predetermined value, and an impedance;

c. said voltage impulse being generated across said impedance upon conduction of said second trigger device.

5. A system as in claim 2 also comprising:

discharge dissipating means connected across said second condenser and operable, upon actuation of said first switch for disconnecting said conductors from said voltage source, to dissipate the charge on said second condenser substantially to zero; whereby upon reclosure of said first switch the initial timing operation of said system is resumed.

6. A system as in claim 1 also comprising:

a. a device adopted to be set in operation by the actuation of said relay;

b. disconnect means also responsive to the actuation of said relay for opening said charging circuit to said first condenser;

c. means responsive to the operation of said device for closing an alternative charging circuit to said first condenser and for opening said alternative charging circuit upon failure of said device to operate;

d. the impedance of said alternative charging circuit being of a value to hold the charge on said first condenser at a value to maintain its discharge current through said relay above said hold-in value;

e. whereby, upon such failure, the discharge current from said first condenser will decay below said hold-in value and said relay will become deactivated.

7. A system as in claim 1 in which said timing circuit includes:

a. a second condenser adopted to be charged from said conductors at the end of said second time delay, to a predetermined voltage;

b. means responsive to said predetermined voltage to generate a periodic series of said voltage impulses, the time between successive of said voltage impulses being less than that required for said first condenser to acquire a charge sufficient to deliver a discharge current through said second circuit having a value above said pull-in value;

c. whereby after said discharge current has dropped below said hold-in value, subsequent discharges of said first condenser through said operating member of said relay will be insufficient to cause said relay to be actuated.

8. A system as in claim 7 also comprising:

a. a device adapted to be set in operation by the actuation of said relay;

b. means responsive to the operation of said device for completing a discharge circuit across said second condenser to discharge said condenser, whereby the generation of said series of voltage impulses ceases and said first condenser is permitted to reach its normal relay operating charge; and

c. means responsive to the stopping of the operation of said device for opening said last named discharge circuit, whereby said timing circuit resumes its generation of said voltage impulses and restarts the initial timing cycle.

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