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[54] **SEMICONDUCTOR CONTROLLED SAFETY TIME DELAY RELAY**
4 Claims, 1 Drawing Fig.

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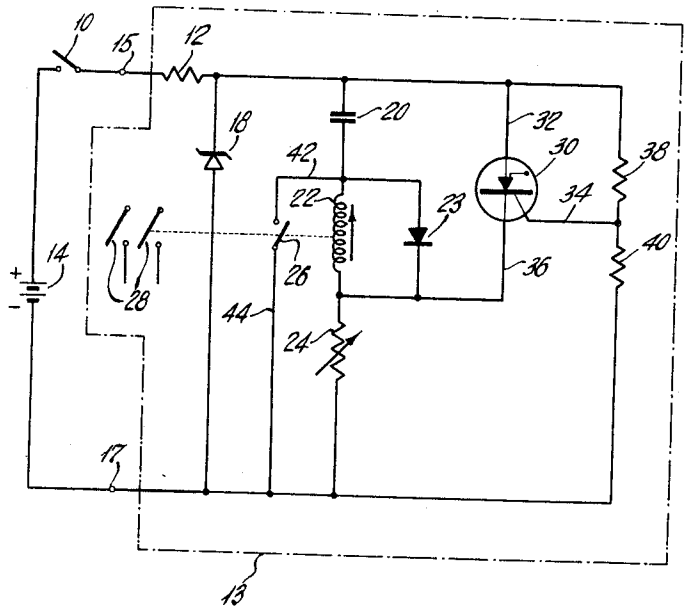
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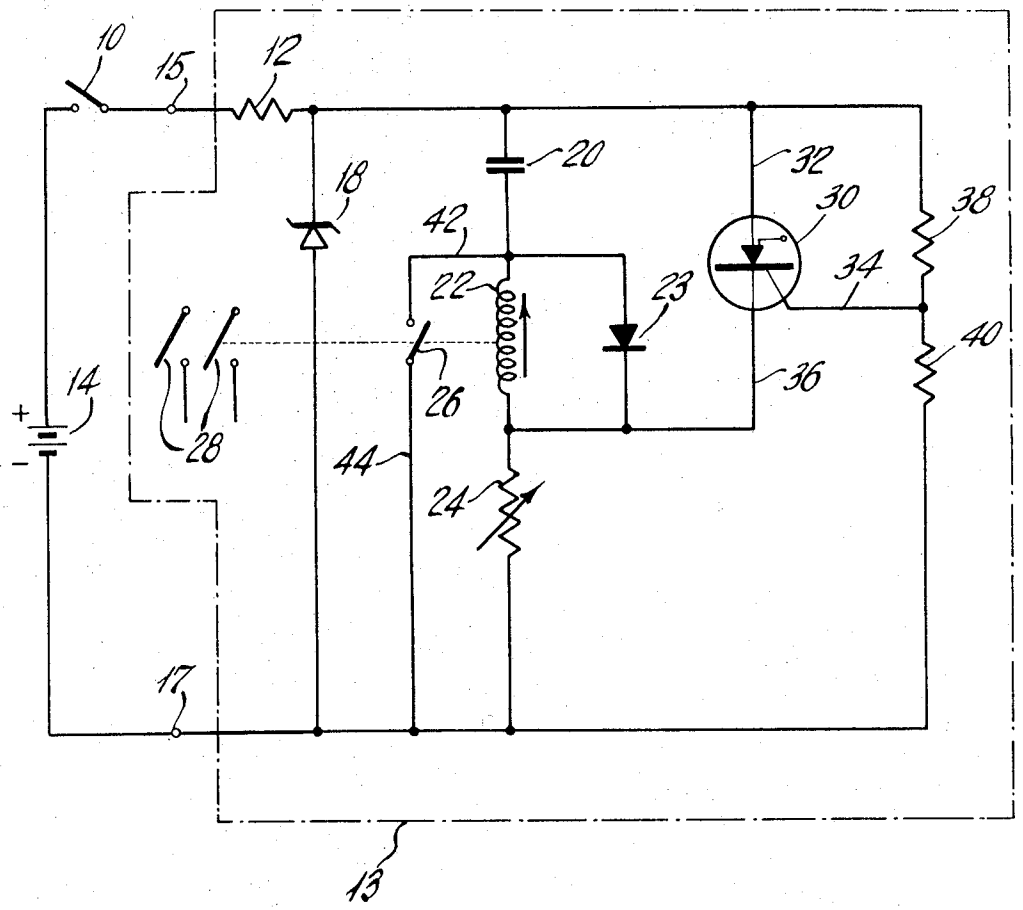
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ABSTRACT: A solid-state circuit is described for controlling a railroad signal delay device wherein the time element is formed by a capacitor and a resistor. A polarized relay is employed in a discharge circuit formed by the capacitor, a semiconductor switch and the coil of the relay. Expiration of the time element operates to close the switch in the discharge circuit. The coil of the relay is so oriented in the circuit that during capacitor charging, the magnetic bias is effectively increased, whereas during the discharge initiated by the closing of the semiconductor switch, the bias is overcome.





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SEMICONDUCTOR CONTROLLED SAFETY TIME DELAY RELAY

This invention relates to railway signal delay devices. More specifically, it relates to a railway safety relay wherein a delay, the time element, is obtained electronically, utilizing a semiconductor switch.

Railway applications of signal delay devices often require a wide range of delay times, say from a matter of seconds to minutes. The conventional delay devices which establish the time element in response to an external switch signal involve electromechanical arrangements such as a pulse oscillator of selected pulse repetition rate driving a stepping motor or a constant speed motor driving the contacts of a switch towards a closed position in a selected time. In both arrangements, a clutch is employed to engage the motors and actuate the time elements as well as quickly disengage the motors when the external switch signal is removed.

Accordingly it is an object of this invention to provide an improved railway signal delay device utilizing semiconductor circuitry having a minumum of moving parts, reduced maintenance and lower manufacturing costs.

An important feature of a signal delay device as employed in railway signalling is that the failure of any component in the device should not cause a reduction in the delay or a premature pickup of the contacts controlled by the delay device. Any failure should rather cause the device to either fail altogether or prolong the delay.

For instance, assume a track block is controlled by a pair of spaced lights which are timed to turn sequentially green after a preselected interval. If the interval is set for a train travelling at 30 miles per hour, then any shortening of the interval will not be noticed for a correspondingly faster-travelling train. On the other hand, if the interval is lengthened, then a faster train cannot pass the block under green light conditions.

Accordingly it is an object of my invention to provide a solid state signal delay device having a minimum amount of components, a high degree of reliability and which is essentially fail-safe in nature.

These objects are accomplished by my invention which is described as follows in conjunction with the drawing which illustrates a schematic representation of the circuitry used in the invention.

Briefly stated, my invention provides the time element with a capacitor charging circuit, the charging circuit controls a polarized relay by including the coil of the relay in a discharge circuit composed of the capacitor of the charging circuit and a semiconductor switch. The relay is magnetically biased and its coil is so oriented in the discharge circuit that discharge currents produce magnetic flux in a direction which overcomes the magnetic bias and thus energizes the relay.

An external contact **10** is operated by a train travelling along a track or other suitable control means and is normally open but, when activated by the passage of a train, closes to supply a DC voltage to the input terminals of the signal delay device **13**. The delay device **13** includes a relay controlling normally open contacts **28** which are to be closed for operation in a railroad signalling circuit (not shown) upon elapse of a preselected time.

Within the signal delay device **13** a Zener diode **18** is coupled to the terminal **17** and through resistor **12** to terminal **17** to provide a regulated supply voltage to the circuitry. A charging circuit is established across the input terminals by the series connection of a capacitor **20**, the coil **22** of a polarized relay and a variable resistor **24**.

In parallel with the capacitor **20** and the coil **22** is a silicon-controlled switch **30** having its anode terminal **32** connected to the input terminal **14**, and its cathode terminal **36** connected to the common junction between the coil **22** and the variable resistor **24**. The cathode gate or trigger terminal **34** of the silicon-controlled switch **30** is connected to the common junction of two series-connected resistors **38** and **40** which are also coupled across the input terminals **15** and **17**.

The polarized relay operates the control contacts **28** and is further provided with a stick circuit including contact **26**. The stick circuit is coupled by line **42** to the common junction between the coil **22** and the capacitor **20** and by line **44** to the input terminal **17**. In parallel with the coil **22** is a rectifier **23** having its anode coupled to the common junction between the coil **22** and the capacitor **20** and its cathode coupled to the common junction formed between the coil **22** and the variable resistor **24**. This rectifier serves to reduce the voltage developed across the coil when contact **10** is closed and may be dispensed with when the switch **30** can tolerate large anode to cathode potentials.

The polarized relay is of the so-called magnetic biased neutral type so that, depending upon the orientation of the coil **22** within the circuit, the current through it will either increase the bias or overcome it. In the former case, the relay will not be energized, whereas in the latter the relay will be activated to operate contacts **28**. For the arrangement shown, the direction of an arrow indicates the direction of current flow in coil **22** to overcome the bias.

The operation of the circuit is as follows. Upon the closing of the external contact **10**, as caused by a train passing a given location, the full terminal voltage is available across terminals **15** and **17**. Since the capacitor initially acts like a short circuit this terminal voltage is effectively placed, at least initially, across the variable resistor **24**. At the same time the cathode gate voltage relative to the cathode is negative, so that the switch **30** cannot conduct and remains open.

As the capacitor **20** charges, the voltage across it increases and the voltage across the resistor **24** decays. This renders the anode to cathode voltage positive and changes the gate to cathode voltage to positive after some time delay; the measured time is a function of(2) a threshold determined by the voltage divider formed by resistors **38** and **40**, as well as (*b*) the time constant of the RC network formed by capacitor **20** and resistor **24**.

When the gate **34** becomes positive with respect to the cathode **36**, the desired time element has expired and the switch **30** is rendered conductive. This closes a discharge circuit formed by the capacitor **20**, the switch **30** and the coil **22**. Discharge of the capacitor **20**, the switch **30** and the coil **22** capacitor now takes place and a current is passed through the coil in the direction of the arrow, opposite to that of the charging current, so that the relay is energized.

The operation of the relay closes the contact **26** of the stick circuit so that as long as the external contact **10** supplies a DC voltage to the circuit, a holding current will continue to flow through the switch **30**, the coil **22** in the direction of the arrow, and the stick circuit. Opening of the external contact **10** will terminate the operation of the relay and return the contacts **28** to their open position.

Variable delays can be obtained by varying the resistance of the variable resistor **24**. Increase of the resistance increases the time for the capacitor to charge and produces the desired longer delay. Also, the resistance **40** may be decreased to increase the time delay.

It can be seen that the breakdown of various elements in the circuit cannot cause premature picking up of the polarized relay. For instance the breakdown of the capacitor **20**, which may occasionally arise because of the large capacitance values needed for long time delays, rather causes a flow of current in the direction that will cause an increase in the bias of the relay coil, so that contacts **28** cannot be operated.

In the event of failure of switch **30**, such as a short circuiting thereof, the shorting current will bypass the relay coil **22** and pass through resistor **24** to the terminal **17**.

The elimination of a clutch and a mechanical mechanism to establish a time element permits a significant reduction in the size of the device The solid state time element can be placed in a single plug-in relay module space while earlier mechanical time element relays required several module spaces.

The preferred embodiment of this invention has been illustrated in connection with a railroad switching application; the

invention, however, may be used in other fields where fail-safe features are important.

I claim:

1. A signal delay device for controlling a railroad signalling circuit or the like with a magnetic biased relay having a stick circuit through one of its sets of contacts and wherein an external contact supplies a DC signal through a pair of terminals to the delay device comprising:

a charging circuit including in series connection across the pair of terminals a capacitor, the coil of said relay and a time element resistor, with the coil oriented in said charging circuit to produce an increase in the bias of the relay from charging current flowing through the coil;

a discharge circuit including said capacitor, said coil and a normally open semiconductor switch arranged to discharge the capacitor through the coil, the discharge current being passed reversely through the coil in a direction to overcome the bias and energize the relay;

means responsive to the DC signal applied from the external contact and said terminals for generating a preselected control voltage for closing the semiconductor switch at a preselected voltage level generated in the charging circuit;

said stick circuit including the coil and the switch in series relationship for passing current through the coil in a direction continuing to overcome the bias of the relay.

2. The device as recited in claim 1 wherein the switch-closing means further comprises said semiconductor switch, said device having a pair of power terminals and a control gate terminal, with said power terminals coupled across the coil and the capacitor, and a pair of series-connected resistors coupled across the DC signal terminals for producing a reference voltage therebetween, with the control gate terminal coupled to the reference voltage for controlling the conduction of the semiconductor switch.

3. The device as recited in claim 1 and further including a bypass rectifier coupled across the coil in a direction for passing charging current around the coil and presenting a high impedance to discharge currents.

4. A signal delay device for controlling a railroad signalling circuit or the like with a relay wherein an external contact supplies a DC signal through a pair of input terminals to the delay device, comprising:

a pair of resistors connected in series relationship across the pair of input terminals;

a semiconductor switching device including a trigger input coupled to the junction between the resistors and having a pair of power terminals;

a capacitor and a time element resistor connected to form a time element network;

said relay being a magnetic biased relay having a coil for actuating the relay in response to current flowing in a first direction through the coil and having plural sets of contacts, a stick circuit including one of the sets of contacts, coupled across the coil to conduct current therethrough to one of the input terminals;

said capacitor and coil connected in series relationship across the power terminals of the semiconductor switch with one of the power terminals of the switch coupled to the other input terminal and the other power terminal coupled through the time element resistor to the one input terminal, said coil having a common junction with the time element resistor and the other power terminal, said coil being oriented to increase the bias in response to charging currents flowing through the capacitor and overcome the bias in response to discharge currents from the capacitor.