TIME DELAY DE-ENERGIZATION OF RELAYS USING THERMISTORS

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FIG. 1

FIG. 2

FIG. 3

FIG. 4

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This invention relates to a circuit for delaying the release or deenergization of electromagnetic relays. It is frequently desirable to provide a delay interval between the occurrence of a control function and the release of an electromagnetic relay in response thereto. For example, telephone circuits employing the step-by-step connector switch are usually caller controlled. Improper timing of this feature by the caller might result in annoying situations. Thus it would be desirable to override the calling party's control over the called party's line for a suitable time interval, for example, 15 to 30 seconds, after the called party hangs up the receiver.

Standard procedures to delay the release time of electromagnetic relays were to use large shunt capacitors in series with a resistance. However, the above arrangement is bulky and expensive and consequently not suitable. It has been proposed to use a thermistor in parallel with the electromagnetic relay for delaying the release of the relay. This approach, although attractive, has not been very popular because it is difficult to control the heat and dissipation properties of thermistors when connected in parallel with electronic devices. As the thermistor resistance can be expressed as a function of the heat generated in it, any thermal coupling to other parallel connected circuits will modify this function. The major problem with the above parallel connected thermistor is that the resistance value of the thermistor had to decrease to a very low value to deenergize the relay thus rendering it more sensitive to external conditions.

It is proposed, in accordance with the invention, to render the parallel thermistor less dependent on external conditions by connecting a semiconductor device in series with the relay. The characteristics of the semiconductor device are such that it responds to an increase in current flow through the thermistor by increasing its own resistance and thus further decreasing the current flow through the relay until the relay is deenergized. Thus the relay is deenergized before the resistance of the thermistor falls down to an objectionably low value.

The invention will now be described with reference to various embodiments illustrative of the invention in which:

FIGURE 1 illustrates a circuit for delaying the release of an electromagnetic relay in which the semiconductor device is a varistor;

FIGURE 2 illustrates a circuit for delaying the release of an electromagnetic relay in which the semiconductor device is a negative temperature coefficient thermistor.

FIGURE 3 illustrates a circuit for delaying the release of an electromagnetic relay using a positive temperature coefficient thermistor in one arrangement as the semiconductor device; and

FIGURE 4 illustrates a circuit for delaying the release of an electromagnetic relay using a positive temperature coefficient thermistor as in another arrangement as the semiconductor device.

In FIGURE 1, there is shown a circuit comprising a relay A connected in series with a semiconductor varistor V₁ and a resistor R₁. In parallel with the series arrangement of the relay and the semiconductor device is a negative temperature coefficient thermistor T₁ in series with a switch S. The circuit is adapted for connection to a source of potential E. The semiconductor device is a varistor which increases its resistance as the current flowing through it decreases.

When the relay is energized sufficient current flows through the varistor V₁ to lower its resistance to a relatively small value. To deenergize relay A on a time controlled basis, switch S is closed to allow current to flow through thermistor T₁. The temperature of the thermistor rises gradually and its resistance decreases. As the current through thermistor T₁ increases, the voltage drop across resistor R₁ increases and the voltage applied to the series combination of the relay coil A and the varistor V₁ decreases. This reduces the current through the relay A and varistor V₁. The impedance of the varistor rises accordingly and further decreases the flow of current through the relay. Thus, varistor V₁ and thermistor T₁ act to reduce the flow of current through the relay below that required to maintain the relay energized without lowering the impedance of the thermistor T₁ to an undesirably low value.

In a practical embodiment of the invention, applicant used a Northern Electric 24 type thermistor having a cold temperature resistance Rₐ of 100 ohms and a Northern Electric 15A varistor having a low resistance of approximately 400 ohms at the current value required to energize the relay A and a resistance of 4000 ohms at the moment of relay release. The value of resistor R₁ was 300 ohms, E was 50 volts and the coil resistance of relay A was 800 ohms. In a circuit using the above components, the relay A was released approximately 25 secs. after closure of switch S. The resistance of the relay T₁ dropped from 100 to 53 ohms. Variations of the voltage E from 50 to 45 volts and/or resistance R₁ from 300 to 150 ohms caused the minimum resistance of thermistor T₁ (at the moment of relay release) to drop from 53 to 29 ohms. However, it was found that such variations did not affect the release time of relay A which occurred about 25 secs. after closure of switch S. Applicant believes that this is due to the fact that the resistance of thermistor T₁ did not have to be reduced below 4 ohms as it was the case when varistor V₁ was used.

FIGURE 2 illustrates a circuit similar to FIGURE 1 wherein varistor V₁ is replaced by a self heated negative temperature coefficient thermistor T₂. When the relay A is energized, thermistor T₂ heats up and its resistance falls from a cold resistance of, for example 300 ohms to 10 ohms. When switch S is closed, thermistor T₁ starts heating up and its resistance decreases. At the same time, the current through relay A decreases and thermistor T₂...
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starts to return to its cold resistance value. For optimum design $T_3$ should be allowed to return to its maximum cold resistance value. When the current through relay A has been reduced below its minimum hold-in value, the relay A is deenergized.

FIGURE 3 illustrates another alternative form of the invention wherein a positive temperature coefficient thermistor $T_3$ is used in series with the relay A in place of varistor $V_1$ in FIGURE 1 or the negative temperature coefficient thermistor $T_2$ in FIGURE 2. Thermistor $T_3$ is mounted in close thermal contact with thermistor $T_1$ and is such that the relay operating current does not heat it. This is normally feasible as the relay may require less than fifty milli-amps to be energized. Upon closing switch S, thermistor $T_3$ draws current and heats up. At the same time, thermistor $T_3$ will start heating up through thermal coupling with thermistor $T_1$, Thermistor $T_1$ will consequently increase its resistance until the current through relay A falls below the minimum hold-in value.

FIGURE 4 illustrates a further alternative form of the invention wherein an indirectly heated positive temperature coefficient thermistor $T_4$ is used in place of thermistor $T_3$ in FIGURE 3. Thermistor $T_4$ has a heater $H$ connected in series with thermistor $T_2$. Upon closure of switch S, the current through heater $H$ will slowly increase under the control of thermistor $T_2$, the resistance $R_4$ and the source of potential E. Thermistor $T_4$ heats up and consequently increases its resistance and thereby further decreases the current flow therethrough until the relay is deenergized.

What is claimed is:

1. A circuit for delaying the release of an electromagnetic relay comprising a series combination of the electromagnetic relay, a positive temperature coefficient thermistor which increases in resistance as its temperature increases and a negative temperature coefficient thermistor adapted for connection in parallel with the relay and the positive temperature coefficient thermistor so that in the flow of current through the negative temperature coefficient thermistor increases the temperature and decreases the resistance of the negative temperature coefficient thermistor to increase the flow of current therethrough and thereby produce a corresponding decrease in the flow of current through the relay and the positive temperature coefficient thermistor, said positive temperature coefficient thermistor being responsive to heat generated by the current flowing through the parallel connection of the negative temperature coefficient thermistor whereby said heat raises the temperature and thereby the resistance of the positive temperature coefficient thermistor, thus decreasing the flow of current through the relay whereby the negative temperature coefficient thermistor and the positive temperature coefficient thermistor cannot to deenergize the relay a predetermined interval after commencement of current flow through the negative temperature coefficient thermistor by progressively decreasing the current through the relay to a value below that required to maintain the relay energized.

2. A circuit for delaying the release of an electromagnetic relay as defined in claim 1 wherein the positive temperature coefficient thermistor is in direct thermal contact with the negative temperature coefficient thermistor and thereby increases the heat generated by the latter due to current flowing therethrough.

3. A circuit for delaying the release of an electromagnetic relay as defined in claim 2 further comprising a resistor in series with the parallel combination of the positive and negative temperature coefficient thermistors.

4. A circuit for delaying the release of an electromagnetic relay as defined in claim 1 wherein the positive temperature coefficient thermistor has a heater connected in series with the negative temperature coefficient thermistor.

5. A circuit for delaying the release of an electromagnetic relay as defined in claim 4 further comprising a resistor in series with the parallel combination of the positive and negative temperature coefficient thermistors.

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