

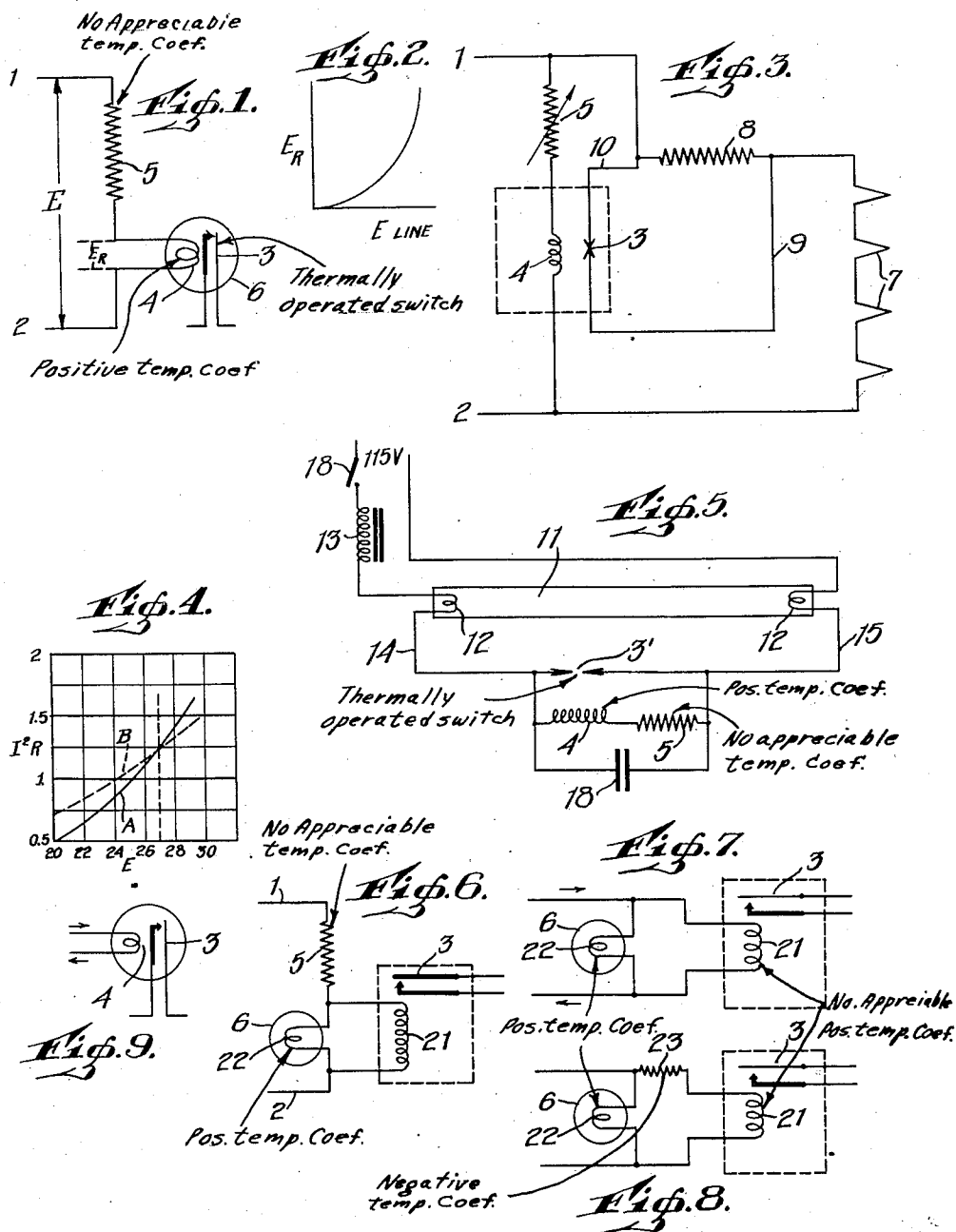
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SENSITIVE RELAY AND CONTROL

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SENSITIVE RELAY AND CONTROL

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This invention relates to relays and relay circuits and control systems including the same.

One object of the invention is a novel and improved relay which is characterized by its marked sensitiveness and selectivity.

A further object of the invention is an improved relay circuit which is characterized by its marked sensitiveness and selectivity.

A further object of the invention is a novel and improved control system embodying the aforesaid relay and circuit.

A further object of the invention is a novel and improved system for controlling the voltage supply to a radio or other consumption circuit.

A further object of the invention is a novel and improved control for starting a gaseous discharge device.

A further object of the invention will herein-after appear.

For a better understanding of the invention reference may be had to the accompanying drawings wherein

Fig. 1 illustrates diagrammatically a relay and circuit embodying the invention;

Fig. 2 is a graph illustrating the principle thereof;

Fig. 3 is a view of a control for a radio circuit embodying the relay of Fig. 1;

Fig. 4 is a graph illustrating the sensitiveness of the control of the circuit of Fig. 3;

Fig. 5 is a view of a control for gaseous discharge lamps as an embodiment of the invention;

Fig. 6 is a view diagrammatically illustrating a modification of the invention; and

Figs. 7, 8 and 9 are diagrammatic views of modified relays and circuits embodying the principle of the invention.

Referring to Fig. 1 of the drawings, the lines 1 and 2 represent a supply circuit furnishing a varying voltage E. The relay of my invention is connected across this line and comprises a control switch 3 to be operated responsively to changes in line voltage E. The switch 3 is directly controlled by an element 4 such for example, as a resistance heater for heating the heat responsive element of the combination. The heater element 4 is of a metal or alloy having a positive temperature resistance coefficient, such for example, as tungsten, iron, nickel or other wire having a similar temperature resistance characteristic. This heating element 4 is placed in series with a resistance 5 and the two elements 4 and 5 are connected in series across the line 1, 2. The resistance element 5 either

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has little or no increase in resistance with increase of current and temperature or it may have a negative temperature resistance coefficient. The relay or relay circuit thus shown has a marked sensitive and selective action in response to voltage changes in the line, that is, the percentage changes in the voltage across the element 4 are greater than corresponding changes in the line voltage E. This is based on the principle that if a resistance having a smaller positive temperature coefficient than that of the tungsten element 4 is connected in series therewith, and the voltage supplied across the combination is varied, the voltage across the resistance with the positive temperature coefficient does not vary in straight line relationship to the variations of the line voltage but rather as shown by the curve in Fig. 2 wherein E_r represents the voltage across the element 4 and E the line voltage. Thus with any change in the line voltage E the change in the voltage across the element 4 is substantially greater in percentage and accordingly by this hookup and proportioning of the elements, the relay can be designed with the sensitiveness and efficiency desired in control circuits where the switch contacts 3 are to be controlled responsively to comparatively small changes in the line voltage E whereby the relay is better enabled to differentiate between the comparatively small changes in the line voltage E and is made more selective.

In setting up the elements 4 and 5 the resistance values should be proportioned so that the element 5 predominates over element 4 or has the predominant or greater portion of the total resistance of the circuit consisting of 4 plus 5. This makes it possible to obtain the sensitive action described. However, if the ratio of the resistance 5 to the resistance 4 were to be increased indefinitely the amount of power actually doing the work consisting of the power dissipated or produced in element 4 would decrease to a point where it would be impractical for the purpose intended. It is therefore necessary to proportion these two resistances so that while sufficient sensitivity of the relay responding to the power produced in element 4 is obtained, at the same time the amount of power produced in element 4 is not decreased to a point where it is insufficient to perform the function.

Best results are obtained when the component parts are so proportioned that the element 4 is operating at a point where there is the greatest change in resistance thereof for any change of current through the same. Thus where the ele-

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ment 4 has a positive temperature resistance coefficient, namely such as the coefficient of tungsten wire, and the resistance 5 has a smaller positive temperature coefficient or practically no coefficient, the relay and circuit are characterized by the marked sensitivity and selectivity pointed out.

The sensitivity and selectivity can be made even more pronounced if the resistance 5 has a negative resistance characteristic such for example as possessed by some of the silicon carbide compounds or else by a resistance having a negative temperature and resistance characteristic. That is, with such a combination and with any given change in the line voltage E the change in percentage of the voltage across the element 4 is still greater where the element 5 has a negative temperature and resistance coefficient.

In Fig. 1 I have shown the element 4 within an envelope 6 which may be evacuated to provide for operation of the element 4 at high temperatures without oxidation.

In Fig. 3 I have illustrated diagrammatically the use of the invention shown in Fig. 1 to control the voltage of the line 1, 2 as supplied to the heating filaments 7 of a radio set. A resistance 8 is interposed in series with the heating filaments 7 to protect the filaments against the supply of an excessive voltage. This resistance 8 is connected across the switch contacts 3 by means of the line conductors 9 and 10 and these contacts 3 are normally closed to short-circuit the resistance 8 and to apply the full line voltage to the heating filaments 7. When the voltage however of the line 1, 2 reaches a certain limit or exceeds a predetermined value the relay opens the contacts 3 so as to insert the resistance 8 in series with the filaments to protect them against the supply of an excessive voltage. For example, the four filaments 7 might be designed for, say 6.3 volts each and the adjustment of the relay and parts and mechanism may be such as to cut the resistance 8 into the circuit if the voltage approaches, reaches or exceeds say, twenty-seven volts. One useful application of the invention is to aircraft radio sets where the supply voltage varies considerably.

In Fig. 4 I have indicated the graph A of a thermal relay having a heater with a pronounced positive temperature coefficient, such as the heater element 4 and another graph B in dotted line of a thermal relay having a heater element which does not have any appreciable positive temperature coefficient, such for example as Nichrome wire. These graphs are plotted showing the I^2R losses with changes in line voltage and as indicated by these graphs a given change in the line voltage E results in a very substantially greater increase in I^2R with the tungsten heater 4 than in the case of the Nichrome heater wire (graph B). The graph A is plotted from actual test results. The graph B is plotted from theoretical values but is regarded as substantially accurate. This is indicative of the marked increase in sensitivity and selectivity of the relay circuit to cut in and to cut out the resistance 8 of the circuit.

As indicated above, the sensitiveness or selectivity are greatest when the component parts of the relay circuit are so proportioned that the heater element 4 is operating at a point where there is the greatest change of resistance for any change of current therethrough.

As stated above, the resistance of element 5 must be much larger than that of the element 4 so as to predominate thereover. For example,

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the resistance of the element 5 is preferably as large as 75% of the total resistance of the circuit (resistance of element 5 plus the resistance of element 4) and it might with advantage be as large as 90% of the total in some cases, as for example, where the element 4, notwithstanding its still smaller percentage of total resistance nevertheless delivers enough power to operate the switch. With a line voltage of 27, a resistance of 67.0 ohms for element 5 and a resistance of approximately 10.0 ohms for element 4 when heated to temperature reached when 0.35 ampere flows, I have obtained the sensitive response indicated in Fig. 4. Any conventional type of thermal switch may be employed, bimetallic, vane, etc. I obtained this sensitive control by the use of a thermal switch of the general type shown in Fig. 8 of the Schmidinger Patent 2,133,309 wherein the heating element 43 is the element 4 and the switch contacts 39, 44' are the contacts 2 of this application and the switch mechanism was mounted in an envelope 6 from which air or oxygen is excluded so as to enable the element 4 to be operated at high temperatures without oxidation.

Still greater sensitiveness would have been obtained if the resistance 5 had had a negative temperature resistance coefficient characteristic because for any given change in the line voltage there is a still greater percentage of the total voltage consumed by the resistance 4.

Fig. 5 shows the application of the invention to the control of the starting of a gaseous discharge device 11. This gaseous discharge device is illustrated as of the conventional fluorescent lamp type having a heater electrode 12 at either end thereof. The supply line is indicated as having a choke coil 13 connected in one side thereof and the line as connected with one end of the heater electrodes 12. The other ends of the heaters 12 are connected through the lines 14 and 15 with the contacts 3' of the thermostatic switch. The contacts 3' are normally open, biased to open position, namely, open when the switch 18 in the supply line is open and also open during the normal operation of the fluorescent lamp 11. These contacts 3' however are closed momentarily for starting by the heat power delivered by the element 4. The elements 4 and 5 correspond generally to the elements above described with respect to Figs. 1, 3 and 4. During the normal operation of the lamp the elements 4 and 5 are connected across the electrode heaters 12 and accordingly the voltage drop across the lamp 11 is supplied to these two elements in series. The I^2R power of the element 4 is insufficient to close the contacts 3' with only the voltage drop of the lamp 11 applied to the elements 4 and 5. At starting, however, namely when the switch 18 is first closed, substantially the full line voltage (115 v.) is supplied to the resistances 12 and the elements 4 and 5 and the heating power of the element 4 is then very substantially increased by reason of the relative proportioning and character of the two elements 4 and 5 as described above. This increased power results in the closing of the contacts 3' and the short-circuiting of the elements 4 and 5 and the consequent reopening of the contacts 3' which are biased to the open position against the heating effect of the element 4. The short-circuiting of the elements 4 and 5 puts the heaters 12 directly across the line with the resultant increased heating of these electrodes so that when the contacts 3' are opened after the momentary closure thereof the

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desired starting kick is delivered to the lamp 11. The voltage drop, as indicated, in the lamp 11 is then insufficient to close the contacts 3' against the bias. Thus by rendering the thermal switch sensitive to the full line voltage but not sensitive to the voltage drop across the lamp 11 to close the contacts 3' a very simple and inexpensive starting mechanism is provided for the lamp. A conventional condenser 18 is connected across the contacts 3'.

Thus the resistance element 5 of Figs. 1, 3 and 5 should have a temperature coefficient of resistance that is algebraically lower than that of the element 4. For instance, if the element 4 has a positive coefficient of resistance, the element 5 may be of a constant resistance, that is a resistance which does not change either with current or temperature. It may be of a resistance which changes with the temperature, that is it has a negative temperature coefficient of resistance, such for example, as carbon. It may also be a resistance having a negative resistance characteristic either wholly independently of the change in temperature or a resistance having a combination of the negative resistance characteristic and the negative temperature resistance coefficient. An example of the latter combination would be silicon carbide compounds, such as that on the market under the name of thyrite.

I have illustrated in Fig. 6 another modification of my improved relay and circuit. In this modification the operating element 21 of the relay of switch contacts 3 is connected across a resistance element 22 of tungsten, iron, nickel or other metal having a positive temperature coefficient of resistance and this resistance element is mounted in an evacuated envelope 6 so as to reduce oxidation at high temperatures. The resistance element 5 is either of a metal or alloy having no appreciable positive temperature coefficient or at least such a coefficient substantially lower than the temperature coefficient of the resistance element 22 or has a negative coefficient as described above with respect to the resistance element 5. The elements 21 and 22 must have different temperature coefficients so as to cause greater percentage changes in voltage across the operating element with increase in voltage supply and this means that the temperature coefficient of 21 must be lower than that of the element 22.

As above described with respect to Figs. 1, 3 and 5, a change in the voltage between the line 1 and 2 is reflected to a greater extent in the resistance element 22 than in the element 5, that is the voltage consumed by the element 22 is increased to a greater percentage and since the operating element 21 of the relay contacts 3 is connected across this resistance element 22 this greater percentage in voltage change is also reflected in this operating element 21. The relay is thus made substantially more sensitive than it would otherwise be and is capable of differentiating between comparatively small changes in line voltage. For best results, as pointed out above, the component parts are so proportioned that the resistance element 22 is operated at a point where there is the greatest change in resistance therein for any change of current through the same and the resistance 5 should be fairly large in comparison to the resistance 22. Also for better results the resistance of the operating element 21 of the relay should be fairly large in comparison to the resistance 22. This operating element 21 is a solenoid which func-

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tions to operate the switch contacts 3. As indicated the relay is still more sensitive if the resistance 5 has a negative temperature resistance characteristic.

The embodiment of Fig. 7 is similar to that of Fig. 6 except that here the relay is current-responsive and its sensitivity and selectivity enhanced. Here the element 22 is connected directly into the line and in shunt to the operating element 21 of the switch contacts 3. Any change in current flowing is reflected to a greater extent in the operating element 21 by reason of the operation of the resistance element 22 which has a high positive temperature coefficient of resistance, the element 21 having little or no increase in resistance.

The embodiment of Fig. 8 is similar to that of Fig. 7 but this embodiment has a resistance 23 having a negative temperature coefficient of resistance such as silicon carbide and silicon carbide combinations connected in series with the operating element 21 of the relay. The resistance element 23 may be of a negative resistance or have a negative temperature resistance characteristic. The selectivity and sensitivity of the relay is thus substantially improved.

In Fig. 9 I have illustrated the principle of the invention as applied to circuits where the relay is to be made current-selective. In this case the circuit requires no external or additional resistance 5. Otherwise this relay or circuit is the same as that shown in Fig. 1.

In the relay circuits of Figs. 1, 3, 5 and 9 the element 4 is the heater of a thermally responsive switch. In the relays and circuits of Figs. 6, 7 and 8 the elements 21 may be either a solenoid magnetically operating and controlling the switch elements 3 or it may be the heating element of a thermal switch means for operating and controlling the switch 3.

I have thus provided a simple and inexpensive relay, relay control and control system for radio sets, fluorescent lamps and the like, all of which controls are characterized by their sensitive, positive and dependable response to comparatively small changes in current and voltages.

I claim:

1. In a control system for the heating circuit of a radio tube set a variable voltage supply line for said circuit, a resistance in said circuit and means responsive to the supply voltage for controlling said resistance comprising a thermally responsive switch to be opened and closed, a controlling element for said switch, a resistance element in series with said controlling element and connected across the supply line, said elements being of different temperature coefficients of resistance with the temperature coefficient of the controlling element being algebraically larger than that of the resistance element to render the controlling element more sensitive to voltage changes and said elements being energized by the supply voltage.

2. In a control system for the heating circuit of a radio tube set a variable voltage supply line for said circuit, a resistance in said circuit and means responsive to the supply voltage for controlling said resistance comprising a thermally responsive switch to be opened and closed, a controlling element for said switch, a resistance element in series with said controlling element and connected across the line, said elements being of different temperature coefficients of resistance with the controlling element having a high positive temperature coefficient of resistance and the

resistance element having no appreciable temperature coefficient and said elements being energized in series by the supply voltage.

3. In a control system for the heating circuit of a radio tube set, a variable voltage supply line for said circuit, a resistance in said circuit and means responsive to the supply voltage for controlling said resistance comprising a thermally responsive switch to be opened and closed, a controlling element for said switch, a resistance element in series with said controlling element and connected across the line, said controlling element having a positive temperature coefficient of resistance and said second-named resistance element having no appreciable positive temperature coefficient and a resistance substantially greater than that of the controlling element.

4. In a control system for the heating circuit of a radio tube set, a variable voltage supply line for said circuit, a resistance in said circuit and means responsive to the supply voltage for controlling said resistance comprising a thermally responsive switch to be opened and closed, a controlling element for said switch, a resistance element in series with said controlling element and connected across the line, said elements being of different temperature coefficients of resistance and said elements being energized in series, said controlling element having a positive temperature coefficient of resistance and said second-named resistance having a negative temperature coefficient of resistance.

5. In a control system for the heating circuit of a radio tube set, a variable voltage supply line for said circuit, a resistance in said circuit and means responsive to the supply voltage for controlling said resistance comprising a thermally responsive switch to be opened and closed for opening and closing a short-circuit about the resistance, and means for controlling said switch including a thermal element, a resistance element connected in series with said thermal element across the supply line, said thermal element

having a high positive temperature coefficient of resistance and said resistance element having no appreciable positive temperature coefficient of resistance and a resistance from three to nine times that of the thermal element.

6. In a control system for the heating circuit of a radio tube set a variable voltage supply line for said circuit, voltage dropping means in said circuit and means responsive to the supply voltage for controlling said voltage dropping means, comprising a thermally responsive switch to be opened and closed, a controlling element for said switch and a resistance element, said resistance element being connected in series with said controlling element across the supply line, said controlling element having a high positive temperature coefficient and said resistance element having a substantially larger resistance than that of the controlling element and having no appreciable positive temperature coefficient.

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