

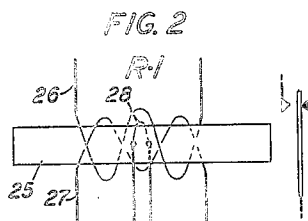
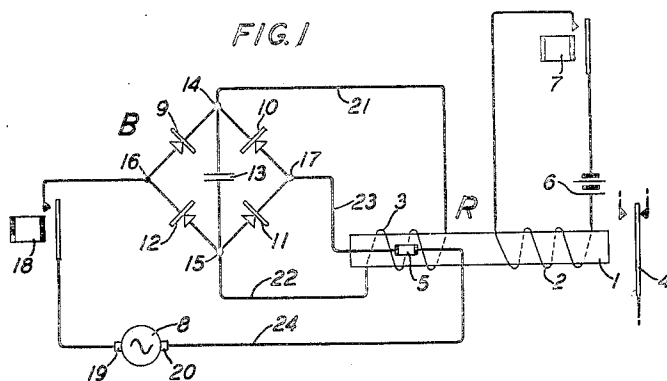
**March 29, 1938.**

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2,112,542

ELECTROMAGNET AND CONTROLLING CIRCUITS THEREFOR

Filed Jan. 17, 1936



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## UNITED STATES PATENT OFFICE

2,112,542

## ELECTROMAGNET AND CONTROLLING CIRCUITS THEREFOR

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Application January 17, 1936, Serial No. 59,513

9 Claims. (Cl. 175—320)

This invention relates to electromagnets and relays, such as those commonly used in communication systems.

The objects of the invention are to maintain a uniformity in the performance of electromagnets and relays under varying operating conditions; to obtain accurate and automatic compensation for variations of temperature; and to improve generally the operating and releasing performance of devices of this kind.

In practice it has been found that the temperature of a relay undergoes substantial variations from time to time. These changes are caused partly by fluctuations in the temperature of the surrounding atmosphere and partly by the resistance losses in the windings of the relay. Since the winding of a relay is usually of some metal, such as copper, having a positive temperature coefficient of resistance, any increase in the temperature of the winding results in a corresponding increase in resistance. This means that the relay obtains less current and less magnetic flux at the higher temperature, and this difference may be sufficient to interfere materially with the proper operation of the relay. For example, a relay that is required to operate on feeble currents over a long circuit may be provided with an auxiliary winding for aiding the operating winding, and in such a case the relay depends for its ability to function upon the difference between one winding alone being energized and both windings being energized.

According to a feature of the present invention, improvements are secured in relays of this kind by connecting in circuit with the relay winding a resistor of some substance having a temperature coefficient of resistance opposite in sign to that of the relay winding and by locating said resistor in physical proximity to the relay winding, so any changes in temperature to which the winding is subjected are also imposed upon the resistor. For instance, if the relay winding is of copper, having a positive temperature coefficient of resistance, the resistor may be of some substance, such as silver sulphide, having a negative temperature coefficient of resistance. As the temperature of the copper winding increases, its resistance increases a definite amount, tending to attenuate correspondingly the current flowing in the circuit of the winding. Since, however, the resistance element undergoes the same temperature change, its resistance decreases a definite amount, tending to increase correspondingly the current flowing in the circuit. By choosing the resistor element of the proper size, shape, and

resistance for the temperature and other conditions under which it is to work, its effect in the circuit will be to compensate accurately for all changes of temperature and to maintain a uniform current and magnetic flux regardless of temperature variations.

Another feature of the invention is a circuit arrangement in which the relay winding and the resistor in series therewith are in circuit with a source of alternating current and a rectifier in such a way that the winding is supplied with unidirectional current, whereas the resistor is supplied with alternating current from said source. This arrangement makes it possible to operate the relay on direct current and at the same time to avoid the application of direct current to the resistor—a condition that is particularly desirable in case silver sulphide is used as the resistor material. The reason is that this substance withstands indefinitely the action of alternating current but deteriorates when subjected to direct current.

The foregoing and other features and advantages of this invention will be set forth more fully in the following detailed description and also in the appended claims.

In the drawing:

Fig. 1 discloses in diagrammatic form a relay and the controlling circuits therefor arranged in accordance with this invention; and

Fig. 2 illustrates a variation in the arrangement of the relay windings.

It is believed that the invention will be best understood from a detailed description, and for this purpose reference is now made to the figures of the drawing. Here the relay R shown in Fig. 1 comprises the usual core 1 of any suitable magnetic material, an operating winding 2, a biasing winding 3, and an armature 4. In addition to these elements the relay R is provided with a resistance element 5 of some material, such as silver sulphide, having a high negative temperature coefficient of resistance. The resistor 5 is mounted as a part of the relay structure and may be disposed in any suitable location with respect to the other parts of the relay. Since it is the function of the resistor 5 to reflect accurately the temperature changes taking place in the winding of the relay, one effective location for the resistor is between the core 1 and the relay winding. Here the resistor 5 is completely surrounded by the winding of the relay and is subject only to temperature changes within the relay and is not directly responsive to fluctuations in the ambient temperature. Also, the resistor 5 can be embed-

ded in the winding of the relay at some suitable distance between the core and the external surface of the winding. There are, of course, numerous ways in which the resistor can be associated intimately with the relay structure, the important consideration being to so locate the resistor that it will detect the temperature changes which it is desired to take into account in applying compensations or other corrections in the operation of the relay.

The operating winding 2 can be connected to any suitable operating circuit which may be controlled by relay contacts or otherwise. As shown, the operating circuit includes a source of potential 6 and the contacts of a relay 7. The biasing winding 3 is supplied with energy from a source of alternating current 8. In order that unidirectional current may be delivered to the biasing winding 3 from the source 8, a rectifying bridge B is interposed between the source 8 and the relay 7. The bridge B is composed of four unidirectional devices 9, 10, 11, and 12 which are arranged to pass current in the direction of the conventional arrows and to oppose the passage of current in the opposite direction. While the type of unidirectional device used in bridge B is unimportant as far as the invention is concerned, rectifiers of the dry type, such as the well-known copper-oxide unit, may be employed. Besides the rectifiers, the bridge B includes a condenser 13 which is connected as shown across the opposite corners 14 and 15 of the bridge.

To the two corners 14 and 15 of the bridge, the two terminals of the biasing winding 3 are connected, and to the other two corners 16 and 17 of the bridge a circuit is connected which includes the source of potential 8 and the resistor 5. The bridge B rectifies the alternating current from the source 8 and delivers unidirectional current to the biasing winding 3 and delivers alternating current without rectification to the resistor element 5. And by the circuit arrangement just described, it is possible to include resistor 5 in series with the winding 3 so that the biasing current flows through both the resistor and the winding, and to limit this current in the winding 3 to a single direction, and to periodically reverse the direction of the biasing current in the resistor 5 in synchronism with the current reversals in the source 8. As has been explained hereinbefore, it is desirable to have the biasing current pass through the resistor 5 in order that the resistor may control the intensity of said current in accordance with the temperature of the relay winding, and, while it is not essential in all kinds of relays to energize the biasing winding by direct current, this may be desirable in some cases. Also, the resistor 5 will serve the same purpose if the biasing current flowing therethrough does not alternate in polarity, but it has been found by experience that some materials, such as silver sulphide, tend to deteriorate more rapidly when subjected to direct current than they do under the influence of alternating current.

The operation of the relay will now be explained. To render the biasing winding 3 effective, the circuit from the source 8 is closed. This may be done in any suitable way, as by means of a circuit closing relay 18. Assume now that at a given instant current is flowing out of the source 8 by way of pole 19 and is returning to the source 8 by way of pole 20. With this assumed direction, current will flow through the contact of relay 18 to the terminal 16 of bridge B,

thence through the rectifier 9, to the terminal 14, over conductor 21, through the biasing winding 3, conductor 22, to the terminal 15, thence through the rectifier 11, to terminal 17, conductor 23, resistor 5, and returning by way of conductor 24 to the source 8. An instant later the current wave passes into the other oscillation of its cycle, and the direction changes. Now current flows out of the source 8 by way of terminal 20, over conductor 24, through the resistor 5 in the opposite direction, thence by way of conductor 23, terminal 17, rectifier 10, terminal 14, conductor 21, through the winding 3, in the same direction as before, conductor 22, terminal 15, rectifier 12, terminal 16, and thence to the opposite pole 19 of the source 8. Thus the flow of current through the winding 3 remains the same throughout the alternating current cycle, while the direction of the current in the resistor 5 changes with each alternation of the current wave. The condenser 13 connected across the terminal corners 14 and 15 of the bridge B is alternately charged and discharged and serves to maintain the current in the biasing winding 3 at a steady value. The current flowing in the biasing winding 3 sets up a flux which conditions the relay for operation. With the winding 3 arranged in aiding relation to the winding 2, the biasing flux established by the winding 3 prepares the relay for operation but of itself is insufficient to cause the actuation of the armature 4. When it is desired to operate the relay, the control relay 7 is energized to close the circuit of the operating winding 2. This produces sufficient flux to attract the armature 4.

The flow of current in the winding 3 produces a power loss which is proportional to the square of the current and to the resistance of the winding. This loss manifests itself in the form of heat, which raises the temperature of the winding. Also, an increase in the ambient temperature will add its effect to the temperature of the relay winding. And, since the relay winding has a positive temperature coefficient of resistance, the higher the temperature of the winding the higher its resistance. This increased resistance of the relay winding lowers the intensity of the current flowing and in turn reduces the amount of biasing flux available for operating the relay armature. This means that the operating winding of the relay is called upon to produce more and more flux to insure the operation of the relay armature. Should the current available for the operating winding become weak, a failure of the relay might result. Accordingly, it is highly desirable that the biasing winding maintains a uniform flux at all times regardless of changes in temperature, and it is to this end that the resistor 5, having a negative temperature coefficient of resistance, is included as a part of the energizing circuit of the biasing winding. With the resistor 5 in intimate contact with the relay winding, the increased temperature of the winding, which causes an increase of its resistance, results in an increased temperature in the resistor, in turn causing a decrease in the resistance of said resistor. By properly selecting the resistor 5 with regard to its physical dimensions and resistance, it is possible to compensate exactly for the changes of temperature and the corresponding changes of resistance of the biasing winding so that the resultant flux produced by the biasing winding is maintained at a constant value regardless of temperature changes.

As suggested hereinbefore, the resistor may be

disposed in any one of a variety of ways on the relay structure. In Fig. 2, for example, the relay R—1 comprises a core 25, a biasing winding 26, an operating winding 27, and a resistor 28. In this case the resistor 28 is illustrated in the form of a short strand which partially encircles the core of the relay and is surrounded by the windings 26 and 27.

Although the description herein refers to silver sulphide as a suitable material for the resistor, it should be understood that any substance may be used, provided it has the proper temperature coefficient of resistance and is suitable in other respects. The essential requirement of the resistor is that it compensates for the change of resistance caused by the change of temperature of the relay winding.

One method of making silver sulphide resistors is disclosed in the patent to Fisher, No. 2,091,259, granted August 31, 1937.

What is claimed is:

1. In combination, a relay winding subject to variations in its temperature, a resistor enclosed by said winding to partake of the temperature variations thereof, said winding and resistor having temperature coefficients of resistance of opposite sign, and a current supply circuit including said winding and resistor.

2. The combination in a relay having a core and a winding thereon of a resistor mounted on said core so as to receive heat from said winding to compensate for changes in the resistance of said winding, and circuit means for supplying current to said winding and resistor.

3. In combination, an electromagnetic winding, a resistor for compensating for changes of temperature in said winding, and means for supplying said winding with unidirectional current and said resistor with alternating current.

4. In combination, an electromagnetic winding and a resistor both of which respond similarly to changes of temperature, a circuit including said winding and resistor in series, and means connected to said circuit for supplying

direct current to said winding and alternating current to said resistor.

5. In combination, an electromagnetic winding and a resistor both of which respond similarly to changes of temperature, a circuit including said winding and resistor in series, and an alternating current source and a rectifier for supplying direct current to said winding and alternating current to said resistor.

6. In combination, a relay having a core and a winding wound thereon, a resistance element having a large temperature coefficient of resistance, said element being mounted on the structure of said relay and in close physical proximity to the relay winding to receive heat from said winding, and means for connecting said element in circuit with said winding to compensate for resistance changes of said winding.

7. In combination, a relay having a core and a winding wound thereon, a resistance element having a negative temperature coefficient of resistance, said element being mounted on the structure of said relay in physical proximity and in heat-conducting relation to the relay winding, and means for connecting said element in circuit with said winding to compensate for resistance changes of said winding.

8. In combination, a relay having a core and a winding thereon, a compensating resistance element embedded in said winding to partake of the temperature variations thereof, and means for connecting said resistance element in circuit with said winding.

9. In combination, a relay having a core, a winding thereon having a positive temperature coefficient of resistance, a resistance element having a negative temperature coefficient of resistance, said element being mounted on the structure of said relay and in close physical proximity to the relay winding to partake of temperature variations thereof, and means for connecting said element in circuit with said winding to compensate for changes of resistance of said winding.

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