March 7, 1944. M. E. REAGAN 2,343,423

RELAY CONTROL SYSTEMS

Filed July 19, 1940

Fig. 1.

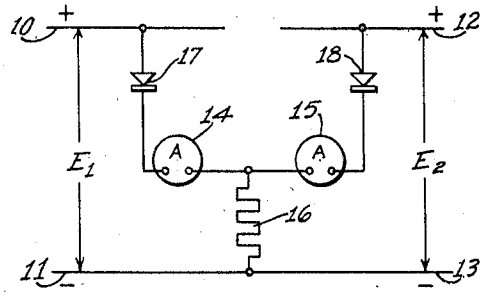


Fig. 2.

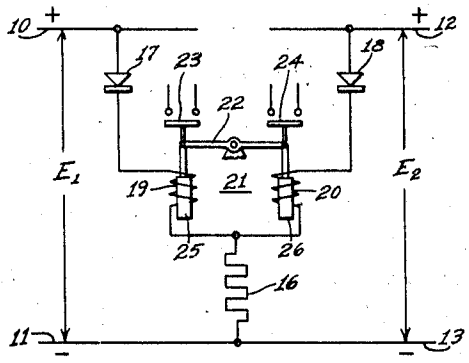
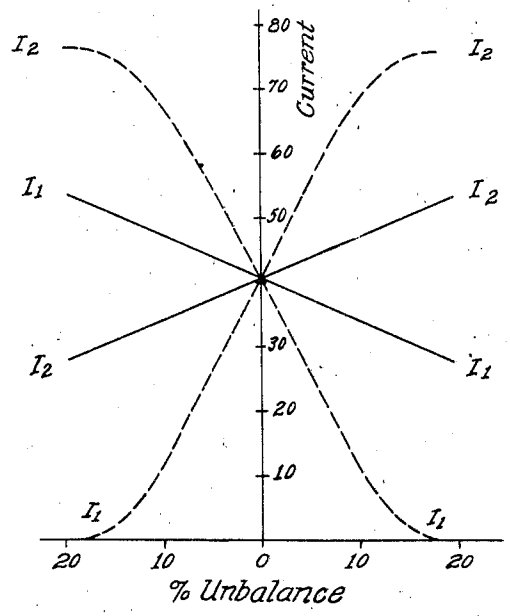


Fig. 3.



WITNESSES:

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2,343,423

RELAY CONTROL SYSTEM

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2 Claims. (Cl. 175—320)

My invention relates, generally, to control systems and, more particularly, to voltage-responsive relay control systems utilizing a relay to effect control functions in accordance with the degree in voltage variation of a circuit or the degree of unbalance between the voltages of two circuits or different parts of the same circuit.

Heretofore, relays of the differential or balance type have been used to perform various control functions in accordance with relative values of voltage between two circuits by simply connecting the opposed or differentially related operating windings of the relay across the circuits in series with a common resistor. While this type of connection has been satisfactory to a certain extent, it has been found that it is not altogether satisfactory for the reason that it is not sensitive to small variations in the voltages of the circuits and there are many applications which require a high degree of sensitivity of control. This defect is not only present in differential relay control systems but also in systems employing a single voltage responsive relay where it is highly desirable that the relay function quickly and positively on a small voltage variation in its supply circuit.

Accordingly, it is the object of my invention, generally stated, to provide a relay control system which is simple and economical to manufacture and which has a high degree of sensitivity.

A more specific object of my invention is to provide for magnifying the degree of energization of the operating winding of a control relay to increase the sensitivity thereof in response to small voltage changes.

A further object of my invention is to provide for increasing the sensitivity of a voltage responsive relay device by utilizing a conductive member which has the inherent characteristic of varying its resistance greatly with current density to magnify the operating current of the relay in response to a predetermined change in the voltage of its supply circuit.

A still further object of my invention is to provide for utilizing a current rectifier device of the dry contact type to increase the sensitivity of a relay connected to effect control functions in response to the variations in the voltage of an electric circuit to which it is connected.

Another object of my invention is to provide for increasing the sensitivity and magnitude of unbalance in a differential or balance relay control system by connecting a current rectifier device of the dry contact type in series with each of the opposed operating windings of the relay.

These and other objects of my invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawing wherein:

Figure 1 is a diagrammatic view of a circuit simulating a balance relay control system illustrating the principles of my invention;

Fig. 2 is a diagrammatic view of a balance relay control system embodying the principal features of my invention;

Fig. 3 is a view illustrating relative degrees of current unbalance in the opposed operating windings of a balance relay with and without the use of current rectifier devices connected in the circuits of the windings.

In practicing my invention in its basic form a current rectifier device or element of the dry contact type such, for example, as a copper-oxide rectifier, is connected in series circuit relation with the operating winding or windings of the relay so as to automatically increase or magnify the current flow therein resulting from a predetermined change in the voltage of the circuit or circuits to which the relay is connected.

Referring now to the drawing, there is illustrated a differential or balance relay control system embodying the principles of the invention. It is to be understood, however, that the principles involved may be applied to other forms of relay control systems wherever it is desired to increase the sensitivity of the relay to predetermined voltage changes.

The principles of the invention are illustrated best in Fig. 1 wherein one circuit or a portion of a circuit is represented by conductors 10 and 11 and another circuit or a part of the same circuit is illustrated by conductors 12 and 13, having voltages E_1 and E_2, respectively, thereon.

If ammeters 14 and 15 are connected across these circuits in series with a common resistor 16, which may be adjustable if desired, the currents I_1 and I_2, flowing in the ammeter circuits will be proportional to the voltages E_1 and E_2 and these currents will vary in direct proportion to the changes in the voltages E_1 and E_2. When E_1 equals E_2 the circuit is balanced and I_1 equals I_2. This is the usual condition found in a balance or differential relay circuit of the type used heretofore.

I have discovered that this condition may be changed in an advantageous way insofar as relay operation is concerned by connecting into each of the ammeter circuits a device whose resistance varies greatly with current density. The most common example of a device of this kind

is a current rectifier of the dry contact type or a rectifier of the barrier layer type exemplified by the copper-oxide rectifier.

Accordingly, if the copper-oxide rectifiers 17 and 18 are connected in the circuits of ammeters 14 and 15, respectively, a decided change occurs in the performance of this circuit as indicated by the curves of Fig. 3.

Fig. 3 shows the relative changes in the ammeter currents resulting from changes in voltages E_1 and E_2. In this instance current values are plotted against per cent unbalance of the circuit. When the rectifier devices 17 and 18 are eliminated from the ammeter circuits the current variation is illustrated by the solid lines I_1 and I_2, I_1 being the current flowing through ammeter 14 and I_2 the current flowing through ammeter 15. If the rectifier devices 17 and 18 are connected in the ammeter circuits, as shown in Fig. 1, the ammeter currents for the same degree of unbalance are illustrated by the dashed lines I_1 and I_2.

Thus it will be apparent that the ammeter currents are magnified to a considerable extent for the same degree of unbalance of the voltages E_1 and E_2 due to the functioning of the rectifier devices 17 and 18. This functioning of the rectifiers is more pronounced in the low current ranges where the current density is low and results from the inherent characteristics of the rectifier of changing its resistance to a greater extent than a corresponding change in the voltage.

A practical application of the principles of the invention is illustrated in Fig. 2 in the form of a balance or differential relay control system. In this instance the ammeters 14 and 15 are replaced by the operating windings 19 and 20 of the differential relay 21. This relay is of well known construction comprising a pivotally mounted member 22 carrying contact members 23 and 24 and which is actuated in opposite directions by the armatures 25 and 26 in response to the energization of the windings 19 and 20.

In the operation of this system when the voltages E_1 and E_2 are equal, the currents flowing through the circuits of windings 19 and 20, i. e., currents I_1 and I_2 are also equal. When a variation or change occurs in either one or both of the voltages E_1 and E_2, resulting in an unbalance of the circuit, the resulting current change is in general as illustrated in Fig. 3 and is the same as explained in connection with Fig. 1.

Accordingly, it will be apparent that when the rectifier devices 17 and 18 are used the magnification of the current change in the operating windings 19 and 20 in response to a predetermined change in voltage greatly increases the sensitivity of the differential relay 21 causing it to respond to smaller voltage variations than would otherwise be possible.

The sensitivity of the system may be varied to some extent by either inserting resistance in series with the rectifier devices 17 and 18 or changing their current density.

This improved operation of the relay not only increases its effectiveness in control applications where it is already in use, but increases its field of application considerably. The increased sensitivity of the relay without the use of expensive and complicated auxiliary equipment adapts it for use in applications where first cost is an important factor.

In view of the foregoing, it will be apparent that the invention provides a simple and inexpensive differential relay control system which may be economically and readily applied to perform any desired control operation in response to predetermined variations in voltage.

While the illustrated embodiment of the invention constitutes a practical and useful example thereof, it is to be understood that other embodiments thereof may be made without departing from the spirit of the invention as defined in the appended claims.

I claim as my invention:

1. The combination with a pair of direct-current electric circuits having one common conductor, of a balance relay having opposed operating windings, a resistor, circuit means individually connecting the relay operating windings across said circuits through said resistor to render the relay responsive to voltage differences of the circuits, said resistor being in series circuit relation to both operating windings, and rectifier means of the contact type connected in said circuit means in series circuit relation with each of the relay operating windings, each of said rectifier means being connected to pass current from the positive to the negative conductors of the electric circuits in the low resistance direction of the rectifier means, thereby to render the balance relay more sensitive to the voltage differences of the electric circuits as the result of the inherent characteristics of the rectifier means of decreasing their effective resistance to current flow in accordance with current density and to a greater extent than a corresponding change in voltage, and the functioning of the resistor to vary the current flow in one operating winding in response to and in the opposite sense to a variation in the current flow in the other operating winding.

2. The combination with a pair of direct-current circuits comprising a common conductor of one polarity and a pair of separate conductors each of the same polarity but of the opposite polarity to that of the common conductor, of a balance relay having opposed operating windings, circuit means individually connecting one terminal of each of the relay windings to one of the pair of conductors, additional circuit means including a resistor common to both of the windings connecting the opposite terminals of the windings to the common conductor, said common resistor functioning to tie the circuits of the relay windings together so that a variation in the voltage of either one of the direct-current circuits to which they are connected not only produces a change in the current flowing in the relay winding connected to that circuit but also produces a change in the current flowing in the other relay winding connected to the other circuit in the opposite sense due to the voltage drop in the common resistor, and rectifier means of the type having a variable resistance dependent upon current density connected in series circuit relation with each of the relay windings to amplify the current change therein to a greater extent than a corresponding change in voltage, whereby the balance relay is rendered more sensitive to the voltage unbalance of the two circuits and its unbalance magnified through the combined functioning of said common resistor and the rectifier means to produce a magnified percentage of unbalance between the currents flowing in the relay windings in response to a variation in the voltage of either direct-current circuit.

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