Dec. 21, 1948. L. G. TUBBS 2,457,011

ELECTRIC CIRCUIT FOR ELECTROMAGNETS

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Fig. 1.

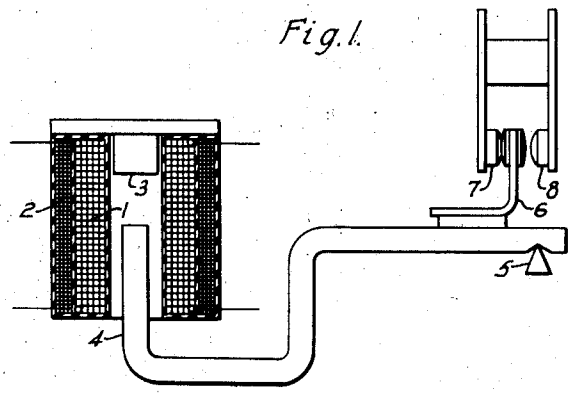


Fig. 2.

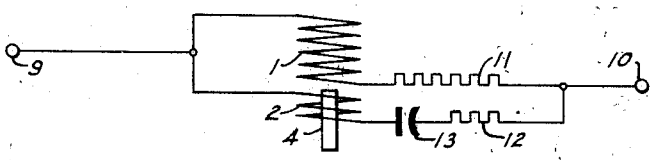
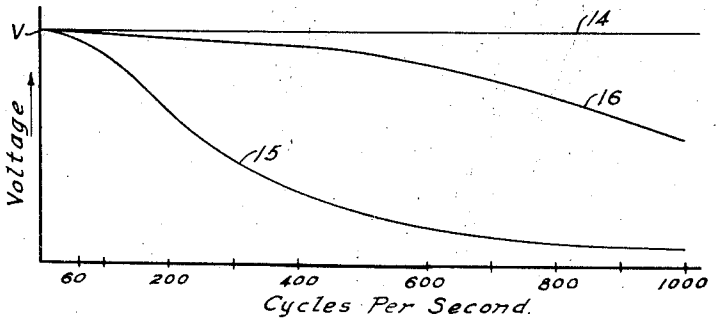


Fig. 3.



WITNESSES:

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ELECTRIC CIRCUIT FOR ELECTROMAGNETS

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My invention relates to voltage-responsive contact relays for alternating-current circuits, for instance, as used in control equipment for feeder voltage regulators.

The performance of regulator control systems and of voltage-responsive contact relays in general, is usually tested by means of conventional portable voltmeters which have a very broad frequency response and consequently indicate R. M. S. voltage including harmonics. The amount of energy required to operate a voltage relay is considerably higher than that of such galvanometers. Hence, it is common practice to apply a large portion of the potential supply voltage across the operating coil of the relay. This results in a large amount of inductance in the circuit of the voltage relay so that the relay responds to harmonic voltages in a much lower degree than a galvanometer. In other words, the presence of harmonics causes discrepancies between the relay operating voltage and the voltage indicated by the voltmeters customarily used for checking the relay performance.

It is an object of my invention to eliminate the just-mentioned discrepancy. More specifically, my invention aims at providing a voltage relay or relay circuit for alternating current which has a flat frequency response, i. e. which maintains an approximately constant sensitivity over a wide frequency range to an extent closely comparable with the voltage-frequency characteristic of a high grade voltmeter.

To this end, and in accordance with a feature of my invention, I provide a voltage relay with a main winding of relatively high inductance and an auxiliary winding whose inductance is only a small portion of that of the main winding, both windings acting cumulatively on the same magnet armature. I connect both windings in parallel between the two terminals of the relay circuit and insert into the parallel path of the auxiliary winding a resistor and a capacitor which are so rated that this path has high impedance at normal frequency and a low impedance at harmonic frequencies. According to another feature of the invention, another resistor is inserted into the parallel path of the main winding in order to maintain the currents in the two paths at about the same phase relation to the operating voltages.

The invention will be more fully understood from the following description in conjunction with the drawing, in which Figure 1 exemplifies a two-coil voltage relay suitable for the invention; Fig. 2 represents diagrammatically the same relay in conjunction with the appertaining other elements of a circuit according to the invention; and Fig. 3 is a diagram typifying the performance of the relay circuit.

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According to Fig. 1, the illustrated relay has a solenoid coil composed of a main winding 1 and an auxiliary winding 2, respectively, which are associated with a common magnetizable pole structure 3. The movable armature 4 of the relay consists of a bent strip, one end of which is pivoted for angular motion on a stationary pivot member 5, while the other end enters into the solenoid opening. A movable contact 6 is mounted on the armature 4 for cooperation with two stationary contacts 7 and 8. In the illustrated position, the armature 4 is biased by its gravity away from the core portion 3 so that contact 6 is in engagement with stationary contact 7. When the relay windings are energized, the armature is attracted toward the core portion 3 so that contact 6 switches into engagement with stationary contact 8.

The two relay windings 1 and 2 are connected in parallel to each other between the terminals 9 and 10 of the relay circuit according to Fig. 2. The parallel path of winding 1 includes a series connected resistor 11, while the cricuit path of winding 2 is provided with a resistor 12 and a series connected capacitor 13.

Main winding 1 is rated to actuate the relay armature 4 under the normal operating conditions of the relay, for instance, at a terminal voltage of 120 volts and 60 cycles. The inductance of winding 2 is so rated that it represents a relatively small fraction of that of winding 1. Referring to the just-mentioned numerical example, the inductance of winding 2 may be about $\frac{1}{5}$ that of the main winding. The circuit path which includes winding 2, capacitor 13 and resistor 12 has a high impedance to the normal operating frequency, but a low impedance to harmonic frequency. Consequently, under normal conditions, the effect of the auxiliary winding 2 is negligible, while at higher frequencies the effect increases thereby compensating for the increased inductance of the main coil at such higher frequencies. Both windings are connected for cumulative action so that the response characteristic of the relay remains approximately constant for an extremely broad range of frequencies including harmonics of the normal frequency. Referring to a normal voltage of 120 volts, 60 cycles, the main coil may be given a resistance of 35 ohms, the resistors 11 and 12 may have 140

and 40 ohms, respectively, and the capacitor 14 may have a capacitance of 7.2 mf.

The performance of such a relay is exemplified by the diagram of Fig. 3 showing the voltage at which the relay responds versus frequency. The straight line 14 represents an ideal response, i. e., a hypothetical relay whose critical voltage is the same throughout the entire range of frequencies. Curve 15 is typical of the known and customary voltage relays, and indicates that the sensitivity of such relays drops considerable in the higher frequency range. Curve 16 is characteristic of the performance of a relay according to the invention. Its departure from the ideal response is slight as compared with the customary relays so that the improved relay responds to R. M. S. voltage, including harmonics, very closely to the way of response of a high grade voltmeter. Consequently, when relays according to my invention are tested, the test results are in accordance with the actual behavior of the relay so that the above-mentioned discrepancies are eliminated.

It will be understood that the numerical examples given in the foregoing are presented for the purpose of illustration and may be modified in accordance with the requirements or desiderata of each intended application. The specific design of the voltage relay is also not essential for the invention and hence can be modified in various respects without departing from the principle of the invention and within the scope of the essential features of the invention set forth in the claims annexed hereto.

I claim as my invention:

1. The combination of an alternating-current voltage relay having a magnet structure provided with two cumulative windings, one of said windings having high inductance, said other winding having low inductance, a parallel circuit connected across said high-inductance winding and including a resistor and a capacitor in series-arrangement with said low-inductance winding so that said circuit has high impedance at normal frequency and low impedance at harmonic frequencies, whereby said relay is caused to have approximately constant voltage sensitivity over an increased range of different frequencies.

2. The combination of an alternating-current voltage-responsive contact relay having a main winding of high inductance, an auxiliary winding of low inductance, and a magnet structure common to said two windings to be cumulatively magnetized by said two windings, two terminals for supplying energizing voltage, said two windings being connected in parallel to each other across said terminals, a resistor and a capacitor interposed in series connection between said auxiliary winding and said terminals so as to provide a circuit of high impedance at normal frequency and low impedance at harmonic frequencies, whereby said relay is caused to have approximately constant voltage sensitivity over an increased range of different frequencies.

3. The combination of an alternating-current voltage-responsive contact relay having an electromagnetic structure with two cumulatively acting windings, one of said windings having high inductance and said other winding having low inductance, two terminals for imposing voltage on said windings, a resistor of high resistance connected in series with said high inductance winding across said terminals, a capacitor and a resistor of low resistance connected in series with said low inductance winding across said terminals so as to provide a circuit of high impedance at normal frequency and low impedance at harmonic frequencies, whereby said relay is caused to have approximately constant voltage sensitivity over an increased range of different frequencies.

4. The combination of an alternating-current voltage-responsive solenoid relay having a main winding of high inductance and an auxiliary winding having an inductance in the order of a fraction of that of said main winding, said two windings being arranged for cumulative action, a resistor connected in series arrangement with said main winding, a circuit connected in parallel to said series arrangement and including a capacitor and a resistor in series-connection with said auxiliary winding, said resistor and said capacitor being rated to provide for said parallel circuit a total resistance whose value is a fraction of that of said arrangement and an impedance which is higher than that of said arrangement for normal frequency and lower than the impedance of said arrangement for harmonic frequencies, whereby said relay is caused to have approximately constant voltage sensitivity at normal and higher frequencies.

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REFERENCES CITED

The following references are of record in the file of this patent:

FOREIGN PATENTS

Number	Country	Date
662,881	Germany	June 30, 1938