

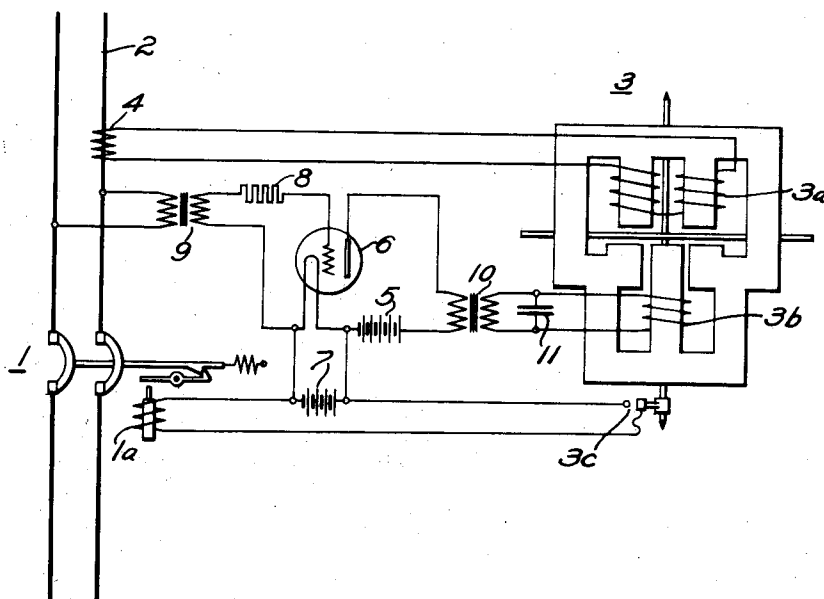
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DIRECTIONAL RELAY ELEMENT

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WITNESSES:

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DIRECTIONAL RELAY ELEMENT

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My invention relates to protective apparatus for alternating-current circuits, and particularly to directional protective apparatus, such as power directional relays and directional elements for protective relays of other types.

The operation of directional elements under fault conditions is often uncertain and slow, because in the event of a fault in the immediate vicinity of the relay, the line voltage may fall to a value which is only a small fraction of normal. The power flow, of course, is always toward the fault, and it would be possible to design the directional element so as to provide sufficient torque for fast, positive action, were it not for the fact that the potential coil of the relay must withstand normal voltage continuously. If the directional element were designed to produce as much torque as would be desirable under fault conditions of minimum voltage, the heating and mechanical forces developed by the potential coil at normal voltage would be beyond permissible limits.

Attempts have been made to improve the performance of directional elements by a variety of expedients, such as utilizing the saturation properties of iron in various ways, but such attempts have not produced satisfactory results. The present practice is to make the moving part of the directional element light in weight, accurately balanced, and mounted on substantially frictionless jewel bearings. Movement of the moving part toward tripping position is opposed only by the inertia of the moving part, and the torque developed under fault conditions is relied upon for operation. Obviously, such an arrangement has its limitations, both as to minimum voltage and operating time, and it is desirable to provide for faster and more positive operation, particularly in high-speed relay applications.

It is an object of my invention to provide a novel arrangement for energizing a directional element which shall provide fast and positive performance under low voltage conditions, and which shall operate substantially without distortion of the relay characteristics.

Other objects of my invention will become evident from the following detailed description taken in conjunction with the accompanying drawing, in which the single figure is a diagrammatic view of directional relay apparatus embodying my invention.

Referring to the single figure, a circuit breaker 1, having a trip coil 1a is provided for controlling the flow of power in an alternating-current transmission or distribution circuit 2. The circuit

breaker 1 is controlled by a directional protective relay of any suitable type, of which, for simplicity, only the directional element 3 is shown. Although the directional element 3 is shown diagrammatically as of the induction type, it will be understood that this element may be of various other forms known in the art.

The directional element 3 is provided with the usual current coils 3a and potential coil 3b. The relay contacts 3c may be biased to open position by any suitable means (not shown) but are preferably permitted to float without bias. Various parts and auxiliaries of the directional element 3, which are familiar to those skilled in the art, but unnecessary to an understanding of my invention have, for simplicity, been omitted from the drawing.

The current coils 3a are energized from the alternating-current circuit 2 by means of a current transformer 4. The potential coil 3b is energized from a suitable direct-current source 5, which serves as the plate supply for a triode 6. The triode 6 may be of any suitable type having characteristics such that its plate current, with constant plate voltage, varies substantially in accordance with grid voltage up to a predetermined minimum saturation value of the latter, and remains substantially constant for values of grid voltage above the saturation value. Although there are various forms of electric discharge devices which have the desired characteristics, it will be assumed that the triode 6 is a hot-cathode electronic tube. The cathode of the triode 6 is connected to a suitable source of cathode current 7, which may also serve as a source of trip current for the circuit breaker 1.

The grid or other control element of the triode 6 is energized through a resistor 8 by means of a potential transformer 9 from the alternating-current circuit 2. The purpose of the resistor 8 is to limit the current which can flow from the grid to the cathode, when the grid is positive, thereby preventing unnecessary destructive action at the grid and excessive positive instantaneous values of grid voltage.

An auxiliary transformer 10 is preferably interposed between the plate circuit of the triode 6 and the potential winding 3b, to eliminate direct-current damping of the directional element 3. A condenser 11 of sufficient capacitance to bring the power factor of the plate circuit approximately to unity, is shunted across any suitable part of the circuit, as across the potential coil 3b. The condenser 11 serves to substantially eliminate the effect of reactive voltages

in the plate circuit, so that the alternating-current component of plate circuit will remain in phase with the grid voltage.

The constants of the various elements associated with the potential coil 3b are so related that the triode 6 saturates at a comparatively low value of grid voltage, for example, that corresponding to 10% of normal line voltage. The alternating current of line frequency supplied to the potential coil 3b, when the triode 6 is saturated, is preferably such as to produce normal excitation in the directional element 3.

The operation will be obvious from the above. During normal line voltage conditions, the triode 6 prevents the excitation of the directional element 3 beyond its normal limits. The same degree of excitation is maintained for all line voltages down to 10% of normal. For line voltages below 10% of normal, the torque developed by the element 3 for a given power value is approximately 10 times that of the usual directional element.

I do not intend that the present invention shall be limited to the specific structural details, arrangement of parts or circuit connections herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of my invention. I desire, therefore, that only such limitations shall be imposed as are indicated in the appended claims.

I claim as my invention:

1. In protective apparatus for an alternating-current circuit, an electric discharge device having a pair of electrode terminals and having electrodes forming a discharge path, said device having characteristics such that the current flow in said discharge path varies substantially in accordance with the voltage applied to said terminals up to a predetermined voltage value and remains substantially constant for voltages above said predetermined value, an output circuit including said discharge path, a directional electro-responsive device having potential terminals energized from said output circuit, and means for energizing said electrode terminals in accordance with a voltage condition of said alternating-current circuit.

2. In protective apparatus for an alternating-current circuit, an electronic device having a saturable discharge circuit, a directional electro-responsive device having potential terminals, and means including said electronic device for energizing said potential terminals in accordance with a voltage condition of said alternating-current circuit, said discharge circuit being arranged to limit the voltage applied to said terminals during normal voltage conditions of said alternating-current circuit.

3. In protective apparatus for an alternating-current circuit, an electric discharge device having a control element and having principal electrodes forming a discharge path, said device having characteristics such that the current flow in said discharge path varies substantially in accordance with an electrical condition of said

control element up to a predetermined value of said condition and remains substantially constant for values of said condition above said predetermined value, an output circuit including said discharge path, a directional electro-responsive device having potential terminals energized from said output circuit, and means for energizing said control element in accordance with a voltage condition of said alternating-current circuit.

4. In protective apparatus for an alternating-current circuit, an electronic device having a saturable discharge circuit, a directional electro-magnetic relay element having a potential coil, and means including said electronic device for energizing said potential coil in accordance with a voltage condition of said alternating-current circuit, said discharge circuit being arranged to limit the voltage applied to said coil during normal voltage conditions of said alternating-current circuit.

5. In protective apparatus for an alternating-current circuit, an electronic device having a grid and having principal electrodes forming a saturable discharge path, an output circuit including said discharge path, a directional electro-magnetic relay element having a potential coil energized from said output circuit, and means for energizing said grid in accordance with a voltage condition of said alternating-current circuit, said discharge path being arranged to limit the voltage applied to said coil during normal voltage conditions of said alternating-current circuit.

6. In protective apparatus for an alternating-current circuit, an electronic device having a grid and having principal electrodes forming a saturable discharge path, an output circuit including said discharge path, a directional electro-magnetic relay element having a potential coil energized from said output circuit, means for energizing said grid in accordance with a voltage condition of said alternating-current circuit, and a capacitor in energy transference relationship to said output circuit, said capacitor being of sufficient capacitance to correct the inductive lag of said output circuit, said discharge path being arranged to limit the voltage applied to said coil during normal voltage conditions of said alternating-current circuit.

7. In protective apparatus for an alternating-current circuit, an electronic device comprising a discharge circuit having an instantaneous current-voltage characteristic such that one of the variables thereof remains substantially constant over a considerable range of the other variable, a directional electro-responsive device having potential terminals, and means including said electronic device for energizing said potential terminals in accordance with a voltage condition of said alternating-current circuit, said discharge circuit being arranged to limit the voltage applied to said terminals during normal voltage conditions of said alternating-current circuit.