

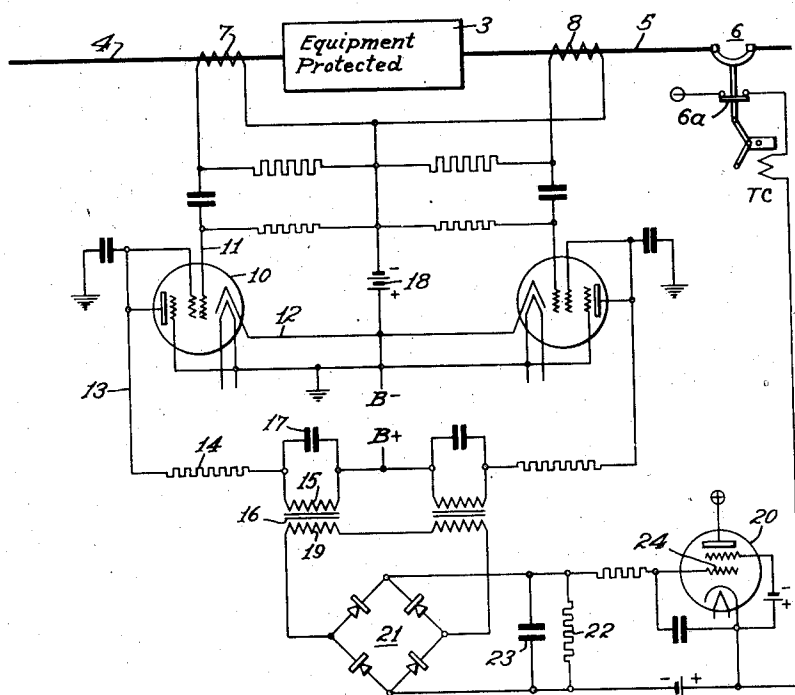
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MODIFIED-CHARACTERISTIC RELAYING APPARATUS

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MODIFIED CHARACTERISTIC RELAYING APPARATUS

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My invention relates to relaying apparatus, and particularly to a general means for obtaining a modified relaying characteristic or response, by means of electric-circuit connections, rather than by the design of the relay-element itself.

An object of my invention is to provide an amplifier-tube means for providing two or more specially controlled single-phase quantities which may be utilized in the control or energization of any type of relaying-means, which is designed to comparatively respond to two or more alternating-current quantities. In a differential-relay combination, for example, the two line-current transformers may be utilized to energize the control-circuits of two amplifier-tubes, the outputs of which may be utilized to perform any desired relaying operation. By simple adjustment of the tube-circuits, or the tube-loading, or the tube-biasing, or by the substitution of the proper kind of tube in the circuit, any desired tube-characteristic may be obtained, varying between a straight-line or linear response, and a substantially saturated response, in which the output of the tube is substantially constant regardless of variations in the input. The tube-outputs are preferably associated with line-frequency segregating-means for segregating the line-frequency components from the direct-current and harmonic components.

A further object of my invention is to provide any sort of non-linear means which is interposed between each of a plurality of sources of alternating-current control-circuit relaying quantities, and the relaying-means which responds to said plurality of quantities, the previously mentioned line-frequency segregating-means being interposed to preserve an approximately sinusoidal wave-form, notwithstanding the wave-distorting effects of the non-linear means.

A further object of my invention is to provide a controlled-circuit means for electrically producing a single relay-controlling single-phase electrical quantity, which embodies within itself all of the discrimination which is desired, in order to obtain any kind of simple or complex current-comparing or current-combining function, as in a linearly responsive differential relay, a relay having a constant-percentage differential-characteristic, a relay having a variable-percentage differential-characteristic, or other types of relays.

With the foregoing and other objects in view, my invention consists in the apparatus, circuits, systems, combinations, and methods hereinafter

described and claimed, and illustrated in the accompanying drawing, the single figure of which is a diagrammatic view of circuits and apparatus illustrating my invention as applied to the differential protection of an electrical equipment.

In the drawing, I have indicated an alternating-current equipment to be protected, at 3, the same having an input line-conductor 4 and an output line-conductor 5. One or both of these line-conductors may be connected through a circuit-breaker 6, which is illustrated as having an auxiliary contact 6a and a trip-coil TC.

The drawing illustrates a differential protective relaying system which is energized from two line-current transformers 7 and 8 which are connected on the two sides of the protected equipment 3.

According to my invention, I provide a separate network for responding to the output of each of the current-transformers 7 and 8, or other sources of control-circuit single-phase electrical quantities. As illustrated, each of the current-transformers 7 and 8 energizes an amplifier-tube 10, the two amplifier-tubes being identical, so that a description of one will suffice for both. I contemplate that any known or desired form of amplifier-tube 10 be utilized, the particular tube which is illustrated being a pentode, although other forms of amplifier-tubes may be utilized. The essential feature of the tube is that it shall have a grid-circuit or other control-circuit 11, a cathode-circuit 12 and a plate-circuit 13, so that the grid-circuit 11 will be the input-circuit of the tube, and the cathode-plate circuit 12—13 will be the output-circuit of the tube. Energy for the output-circuit of the tube is supplied by means of any suitable direct-current source which is indicated by the B-battery terminals B+ and B—.

In accordance with my invention, the output-circuit 12—13 of each of the amplifier-tubes 10 comprises a loading-resistance 14 and a tuned, parallel-resonant circuit which comprises the primary winding 15 of an iron-core transformer 16, the primary winding 15 being shunted by means of a capacitor 17 which is tuned to the primary-winding inductance so as to be resonant at the line-frequency of the protected equipment 3, although, in an alternative construction, the tuned circuit could conceivably be tuned to some harmonic. By utilizing a tuned circuit 15—17 having a sufficiently high Q, and by utilizing a sufficiently large loading-resistance 14, it is possible to utilize the tuned circuit 15—17 to selectively segregate the line-frequency com-

ponent, or the selected harmonic thereof, as distinguished from the direct-current component and the remaining harmonic components of the current flowing in the output-circuit 12-13 of each of the amplifier-tubes 10. By properly choosing amplifier-tubes 10 having the desired tube-characteristics, and by properly choosing the magnitude of the tube-loading resistance 14, the B-battery voltage, and the voltage of the biasing or C-battery 18, any desired type of tube-characteristic may be obtained.

The line-frequency transformers 16 are shown as being provided with secondary windings 19 which are utilized, in accordance with my invention, to provide the energy for actuating or controlling any desired relaying-apparatus, in lieu of directly utilizing the energy which is supplied by the two line-current transformers 7 and 8. This output-energy of the transformer-secondaries 19 may be utilized, either directly, or through the intermediary of any desired amplifier-means which is not shown except that I have shown a system in which the output-energy is utilized to energize a relaying-tube 20, which itself serves as an energy-amplifying means.

The outputs of the two transformer-secondaries 19 are combined so that they augment each other for an internal fault in the protected equipment, and oppose for an external fault. These two transformer-outputs are applied, through a rectifier-bridge 21, to a unidirectional-current circuit including a resistor 22. It is generally preferable to smooth out the ripples from the unidirectional-current circuit, as by means of a shunting capacitor 23, which is intended to be representative of any ripple-suppressing means.

The voltage which appears across the resistor 22 is applied to the control-grid 24 of the relay-tube 20, which thus serves as a relay-means. Although I am not limited to the particular choice of relay-tube 20, I have chosen to illustrate a thyatron, or a gas-filled tube which will fire when the direct-current grid-voltage is equal to, or more positive than, a predetermined value which can be changed by altering the constants of the tube-circuits. I have also chosen to illustrate a relay-tube 20 of the double-grid type, so that it may be operated to have a constant grid-firing voltage, relatively independently of circuit-variations.

The plate-cathode circuit of the relay-tube 20 is utilized to energize the trip-coil TC of the breaker 6, through the auxiliary breaker-switch 6a.

The use of a tube-type tripping-relay 20 means that my relaying system is inherently of a high speed. However, simple variations are possible, to introduce time-delays in a known manner, if required.

In the operation of the new differential relaying-apparatus which is shown in the drawing, the presence of the amplifier-tubes 10 makes it possible to perform the various types of response-modifications electrically, by way of modified electric currents and voltages, which may be electrically combined, and applied to a simple overcurrent or overvoltage relaying-means, in the form of a single, compositely responsive, single-phase line-frequency current which is the current resulting from the combined outputs of the two transformer-secondaries 19.

If the amplifier-tubes 10 are so chosen, and so loaded by the resistors 14, that their dynamic operating characteristic is a straight line over the operating range, so that their outputs are re-

spectively responsive linearly to their inputs, the differential-relay response will be such as to require a constant difference between the input and output line-currents, in order to trip the circuit-breaker 6. If the amplifier-tubes 10 and their associated circuits are so operated that the output remains relatively constant with respect to variations in input, i. e., the dynamic operating characteristic of the amplifier is saturated, which is perhaps the most important adjustment according to my invention, the differential-relay characteristic will have a variable-percentage characteristic, which means that its sensitivity will be reduced at higher values of current, so as to prevent false operations due to poorly matched saturation-characteristics of the two current-transformers 7 and 8. It will be noted that this variable-percentage characteristic is obtained in a simple overcurrent or overvoltage-responsive relay-member 20, which avoids the use of complicated mechanical relays having restraint-elements or restraining torques. Other relay-characteristics may be obtained by intermediate adjustments of the operating-characteristics of the amplifier-tubes 10 and their associated circuits.

In polyphase equipments, if my invention is utilized in a differential relay, the drawing may be regarded as a single-line diagram, representing one phase of the equipment, or representing, in the relay-current sources 7 and 8, any phase-sequence or other networks or means for deriving single-phase input and output currents for comparison by my device.

While I have illustrated my invention in an illustrative form of embodiment, which is at present preferred, I wish it to be understood that this form of embodiment is merely illustrative, and that my invention is susceptible of considerable variation in details of execution, without departing from the essential principles of the invention, I desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language and the prior art.

I claim as my invention:

1. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, amplifier-tube means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities, means for substantially segregating an alternating-current component from the direct-current component of each of the output-quantities, means for combining all of said alternating-current components and for producing a single, compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

2. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, non-linear means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities of controlled characteristics, including fundamental and harmonic components of different frequencies, means for substantially segregating a component of one particular frequency from the other components of each of the output-quantities, means for combining all of said selected-frequency components and for producing a single,

compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

3. The combination, with a relaying-means for responding to two controlling alternating-current quantities of the same line-frequency but subject to variation in magnitude or phase relationships, of two supply-circuits for supplying two such quantities for controlling said relaying-means, and an amplifier-tube means and frequency-responsive segregating-means interposed between each supply-circuit and the corresponding control-circuit terminals of said relaying-means for supplying substantially sinusoidal controlling quantities to said relaying-means.

4. The combination, with a relaying-means for responding to two controlling alternating-current quantities of the same line-frequency but subject to variation in magnitude or phase relationships, of two supply-circuits for supplying two such quantities for controlling said relaying-means, and a non-linear means and frequency-responsive segregating-means interposed between each supply-circuit and the corresponding control-circuit terminals of said relaying-means for supplying substantially sinusoidal controlling quantities of modified characteristics to said relaying-means.

5. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, amplifier-tube means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities, means for substantially segregating the component of one particular frequency from each of the output-quantities, and means for differentially comparing said segregated components.

6. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, non-linear means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities of controlled characteristics, means for substantially segregating the component of one particular frequency from each of the output-quantities, and means for differentially comparing said segregated components.

7. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two amplifier-tube means for responding selectively to said input and output currents and for producing respective output-quantities, means for substantially segregating the component of one particular frequency from each of the output-quantities, and means for differentially comparing said line-frequency components.

8. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two non-linear means for responding selectively to said input and output currents and for producing respective output-quantities of modified characteristics, means for substantially segregating the component of one particular frequency from each of the output-

quantities, and means for differentially comparing said line-frequency components.

9. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two amplifier-tube means for responding selectively to said input and output currents and for producing respective output-quantities, means for substantially segregating the component of one particular frequency from each of the output-quantities, means for combining said line-frequency components and for producing a single, compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

10. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two non-linear means for responding selectively to said input and output currents and for producing respective output-quantities of modified characteristics, means for substantially segregating the component of one particular frequency from each of the output-quantities, means for combining said line-frequency components and for producing a single, compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

11. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, amplifier-tube means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities, means for substantially segregating the line-frequency component from the direct-current component of each of the output-quantities, means for combining all of said line-frequency components and for producing a single, compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

12. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, non-linear means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities of controlled characteristics, means for substantially segregating the line-frequency component from the harmonic components of each of the output-quantities, means for combining all of said line-frequency components and for producing a single, compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

13. The combination, with a relaying-means for responding to two controlling alternating-current quantities of the same line-frequency but subject to variation in magnitude or phase relationships, of two supply-circuits for supplying two such quantities for controlling said relaying-means, and an amplifier-tube means and line-frequency segregating-means interposed between each supply-circuit and the corresponding control-circuit terminals of said relaying-means for supplying substantially sinusoidal controlling quantities to said relaying-means.

14. The combination, with a relaying-means for responding to two controlling alternating-current quantities of the same line-frequency but subject to variation in magnitude or phase relationships, of two supply-circuits for supplying two such quantities for controlling said relaying-means, and a non-linear means and line-frequency segregating-means interposed between each supply-circuit and the corresponding control-circuit terminals of said relaying-means for supplying substantially sinusoidal controlling quantities of modified characteristics to said relaying-means.

15. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, amplifier-tube means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities, means for substantially segregating the line-frequency component from each of the output-quantities, and means for differentially comparing said line-frequency components.

16. Alternating-current relaying apparatus comprising a plurality of sources of alternating-current control-circuit relaying quantities of the same line-frequency but subject to variation in magnitude or phase relationships, non-linear means associated with each of said sources for responding to said control-circuit relaying quantities and for producing respective output-quantities of controlled characteristics, means for substantially segregating the line-frequency component from each of the output-quantities, and means for differentially comparing said line-frequency components.

17. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two amplifier-tube means for responding selectively to said input and output currents and for producing respective output-quantities, means for substantially segregating the line-frequency component

from the direct-current and harmonic components of each of the output-quantities, and means for differentially comparing said line-frequency components.

18. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two non-linear means for responding selectively to said input and output currents and for producing respective output-quantities of modified characteristics, means for substantially segregating the line-frequency component from each of the output-quantities, and means for differentially comparing said line-frequency components.

19. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two amplifier-tube means for responding selectively to said input and output currents and for producing respective output-quantities, means for substantially segregating the line-frequency component from each of the output-quantities, means for combining said line-frequency components and for producing a single, compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

20. Differential relaying apparatus for comparing the input and output currents of an alternating-current equipment to be protected, comprising, in combination with means for deriving said input and output currents, two non-linear means for responding selectively to said input and output currents and for producing respective output-quantities of modified characteristics, means for substantially segregating the line-frequency component from each of the output-quantities, means for combining said line-frequency components and for producing a single, compositely responsive, single-phase quantity, and relaying-means responsive to said last-mentioned quantity.

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