No. 818,424. PATENTED APR. 24, 1906.

G. N. EASTMAN.

SAFETY DEVICE FOR ALTERNATING CURRENT DISTRIBUTION.

APPLICATION FILED SEPT. 17, 1904.

2 SHEETS—SHEET 1.

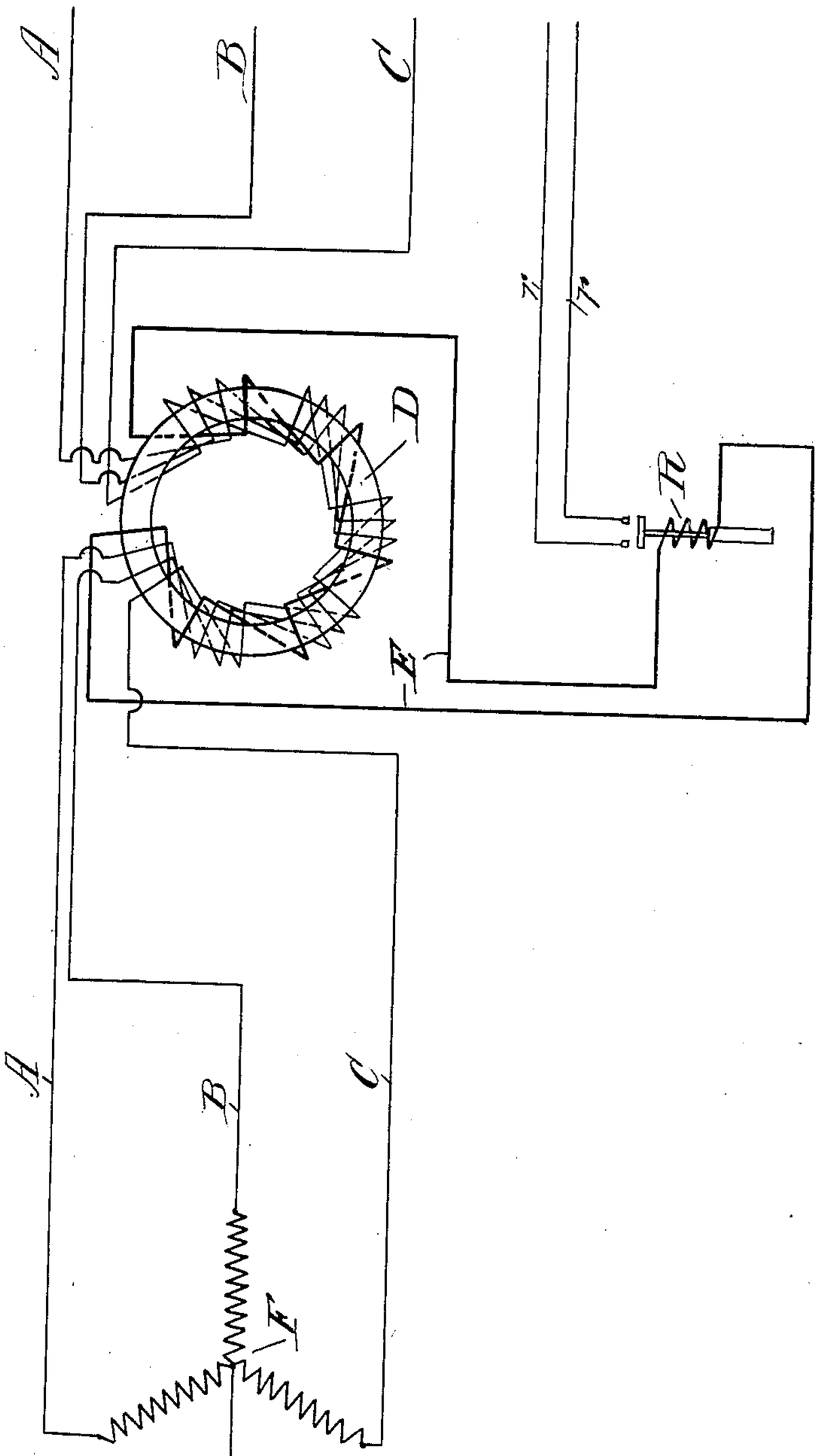


Fig. 1.

Witnesses:
Harry R. Lubke
R. White

Inventor
George N. Eastman.
By Howard M. Cox
Atty.

No. 818,424. PATENTED APR. 24, 1906.

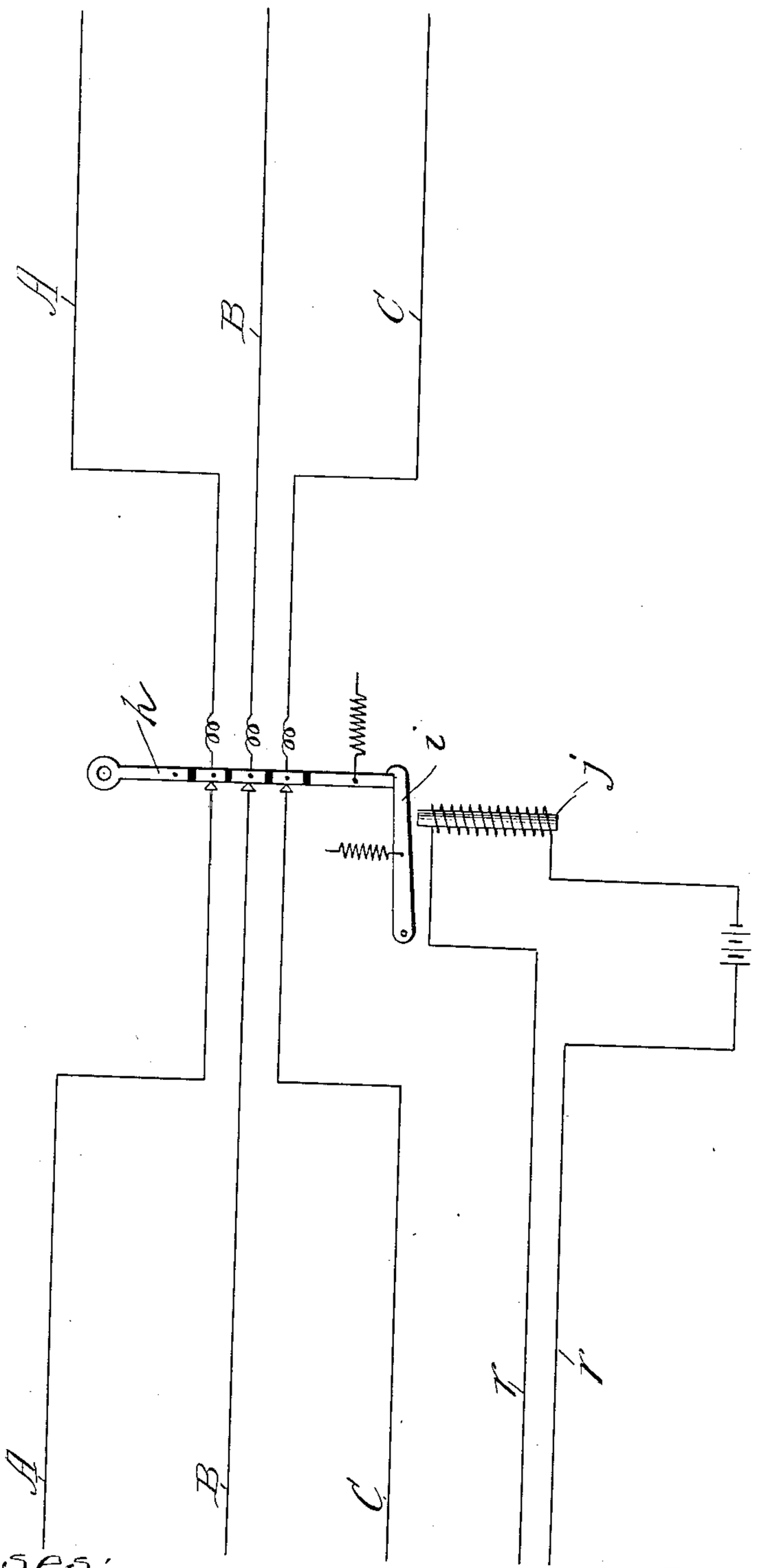
G. N. EASTMAN.

SAFETY DEVICE FOR ALTERNATING CURRENT DISTRIBUTION.

APPLICATION FILED SEPT. 17, 1904.

2 SHEETS—SHEET 2.

Fig. 2.



Witnesses:
Harry R. L. White
Ray White.

Inventor
George N. Eastman
By Howard M. Cox
Atty

UNITED STATES PATENT OFFICE.

GEORGE N. EASTMAN, OF CHICAGO, ILLINOIS.

SAFETY DEVICE FOR ALTERNATING-CURRENT DISTRIBUTION.

No. 818,424. Specification of Letters Patent. Patented April 24, 1906.

Application filed September 17, 1904. Serial No. 224,828.

To all whom it may concern:

Be it known that I, GEORGE N. EASTMAN, a citizen of the United States, residing at the city of Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Safety Devices for Alternating-Current Distribution, of which the following is a specification.

My invention relates to safety appliances for use in alternating-current-distributing systems employing two or more conductors; and the object of the invention is to provide an electrosensitive device adapted to be automatically operated from an alternating-current system for indicating a ground or breaking the circuit on which a ground occurs.

In the accompanying drawings, which form a part of this specification, I have illustrated my invention in one of its many possible forms—to wit, a form applicable to the common three-wire system connected to a star-wound grounded alternating generator.

Figures 1 and 2 are placed on separate sheets to obtain a suitable scale of drawing; but the two figures taken together represent, diagrammatically, a single apparatus.

Referring to the drawings, F represents an alternating generator connected to the distributing-conductors A B C and grounded at G in the usual manner. Said conductors A, B, and C are each wound with an equal number of turns upon the preferably laminated iron-ring core D in such manner that each will have the same inductive effect upon said core. Said conductors A B C are of course insulated from each other and from the core D and for the purpose of illustration may be considered to be covered by any suitable insulating material. It is desirable not only that the windings should induce the same strength of magnetic flux in the core, but that the windings should all be distributed in the same manner over the core, and this may be obtained by winding the conductors over the core simultaneously, as suggested in the drawings, (each being of course suitably insulated,) or said line conductors A B C may be wound in three different layers, one on top of the other, each with an equivalent number of turns and each layer being properly insulated. From said core said conductors A B C may lead either to a line-current transformer or to the distributing-lines direct. An independent conductor E is also wound about core D in such manner that any magnetic flux therein will induce a current in said conductor. The manner of winding is not essential, and it may be wound simultaneously with the conductors A B C, as suggested in the drawings, or it may constitute a complete or partial layer upon core D, insulated, of course, from said core and from the other conductors. Said conductor E is connected to a safety device—for example, the relay R—adapted to operate the circuit-breaker illustrated in Fig. 2. The form of circuit-breaker is immaterial, the illustrated form consisting of a switch *h*, adapted to control the circuit in the lines A, B, and C. Said switch is spring-influenced to open and is held in closed position by means of the hooked arm *i*, spring-influenced to remain set. Said arm is released by the solenoid *j* in the relay-circuit *r*.

In operation so long as there is no escape of line-current from any of the lines A, B, or C to the ground the currents through their respective windings on core D will neutralize each other and no flux will result in said core. As soon as a ground occurs, however, part of the current fed through the transformer will return to the generator F through the ground, and thus destroy the balance in the current-transformer or line. This will cause a magnetic flux to be set up in the core D, which will in turn energize the winding in the conductor E, thus operating the relay R and switch *h* to break the circuit. It will be understood, of course, that instead of a circuit-breaker other safety devices may be substituted, such as an indicator of the galvanometer type, employing a needle deflected through the action of its motor element when subjected to the current in the local circuit E.

It has been found in actual practice in high-tension systems, especially in underground-cable work, that in nearly all cases the short circuits have first started as a short circuit between one conductor and ground and subsequently developed into a short circuit between two conductors. Under the usual operating conditions a little time would elapse before the insulation would burn sufficiently to result in a short circuit between conductors. The interim would be sufficient for the operation of my device, and consequently by employing it a ground may be detected and removed from the system before it has had time to develop into a short circuit between conductors. As a result, the trouble will be limited to a single line and such part of the system as is effected thereby.

My device is applicable to any polyphase system employing two or more conductors. In any single polyphase system the sum of all of the currents is equal to zero, and therefore it makes no difference with my device whether the load on the circuit is balanced or not. Nothing except a ground or a shunt will produce any flux in the core. It is not necessary that the generator be grounded, for the return may be effected through the electrotstatic capacity of the line conductors or mains of the system. To illustrate, take the example of a three-phase underground-distribution system where the generator is not grounded and employing cable consisting of three conductors inclosed in a sheath of lead. In such case there will be a condenser action in the cable itself, for although the resistance through the insulation covering each conductor is high there is nevertheless some flow between conductors and even between the conductors and the sheath, the sheath being, electrically considered, the same as ground. In such a system the electrostatic capacity between conductors and ground will normally be balanced, and the charging-current will therefore be the same on all three conductors; but in case of a ground on one of the conductors the condenser between that conductor and ground will be short-circuited, or, in other words, there will remain no condenser action between that conductor and ground. The potential between the other two conductors and ground will consequently be raised and the charging-current through the grounded conductor will be increased. This would of course throw the system out of balance, and core D would be energized and operate the safety device as before.

Although it is preferable to use a closed-circuit metallic core, the core may not be closed, and it would even be possible to entirely omit the core and permit the induced magnetic lines of force to pass through the air, the coils being wound the same as before in such manner that their mutual inductances would bear the same relationship to each other. There may be times in a three-wire system, for example, when there is current flowing in only two of the main conductors, the third temporarily carrying none. Under such conditions, however, the vectorial sum of the currents will still be zero so long as no current is through accidental ground or other shunt, and the currents would therefore still be balanced and cause no energizing of core D.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. An automatic safety device for alternating currents consisting of a plurality of circuit-conductors arranged on different sides of the system and their electromotive forces differing from each other in phases a group of independent windings insulated from each other, one for each of the circuit-conductors, arranged in close proximity and bearing the same inductive relationship to each other, whereby the inductance is neutralized when the vectorial sum of the currents in the circuit-conductors is zero; and an extra coil for controlling an electrosensitive device, said extra coil being in position to be inductively energized by any one of the first-mentioned coils.

2. An automatic safety device for alternating currents consisting of a plurality of line conductors arranged on different sides of the system and their electromotive forces differing from each other in phase a core having the line conductors insulated therefrom and from each other and wound substantially in balance thereon; and an electrosensitive device adapted to be influenced by magnetic flux in said core.

3. An automatic safety device for alternating currents consisting of a plurality of line conductors arranged on different sides of the system and their electromotive forces differing from each other in phase a core having the line conductors wound substantially in balance thereon said line conductors being electrically non-connected; an electrosensitive device; and a conductor connected to said electrosensitive device and having a portion wound around said core to be energized by the magnetic flux therein.

4. In a distributing system for alternating currents, the combination of a magnetic core; a set of line-conductors insulated from each other and arranged on different sides of the system and differing in phase from each other wound on said core in balance so that at any portion of said core the vectorial sum of the electromotive forces is substantially zero; an electrosensitive device; and an independent winding on said core connected to said electrosensitive device for operating the same when said core has magnetic flux set up therein.

5. In a distributing system for alternating currents, the combination of a metallic ring; a set of line conductors insulated from each other and having independent windings of an equal number of turns upon said ring; said line conductors being arranged on different sides of the system and differing in phase from each other; an electrosensitive device; and a separate conductor connected to said electrosensitive device and making a number of turns around said ring.

6. In a distributing system, the combination of an alternating generator; three line conductors connected thereto on opposite sides of the system whereby their electromotive forces differ from each other by one-third of a period; a magnetic core; three equivalent windings around said core electrically connected to said line conductors and insulated

from each other; and an electrosensitive device adapted to be operated by magnetic flux in said core.

7. In a three-phase, alternating system of electric distribution, the combination of an alternating generator; three line conductors leading therefrom and differing in phase by one-third of a period; a closed-circuit magnetic core; three independent windings insulated from each other and symmetrically arranged on said core and connected to said line conductors, and an electrosensitive device adapted to be operated by magnetic flux in said core.

8. In a three-phase, alternating system of electric distribution, the combination of an alternating generator; three line conductors connected thereto so as to differ in phase by one-third of a period; a laminated iron ring; three independent windings of an equal number of turns symmetrically wound around said ring and insulated from each other; a fourth winding wound around said ring symmetrically with respect to the other three windings; and an electrosensitive device operated by said fourth winding when a current is induced therein.

9. A system of alternating-current distribution having a circuit-breaker for its mains and apparatus governing the circuit-breaker, said apparatus including inducing-windings all insulated from each other and their currents differing in phase from each other, and each main of the system including one of said inducing-windings, and said apparatus also including a circuit having a winding in transformer relation with each of said inducing-windings.

10. A system of alternating-current distribution having a circuit-breaker for its mains, which mains differ from each other in phase, apparatus governing the circuit-breakers, said apparatus including inducing-windings each in a main of the system and insulated from each other, a secondary winding in transformer relation with each of the inducing-windings and a magnet governing the circuit-breaker and receiving current from the secondary winding substantially as described.

11. A polyphase system of alternating-current distribution having a circuit-breaker for its mains, said mains differing from each other in phase, apparatus governing the circuit-breaker, said apparatus including a core having windings thereon each included in a main of the system, and each insulated from the other and having their electromotive forces differing in phase, said apparatus also including a secondary circuit having a winding in transformer relation with each of said inducing-windings.

13. A system of alternating-current distribution having three mains arranged on different sides of the system and differing from each other in phase by one third of a period, a circuit-breaker for said mains and apparatus governing said circuit-breaker, said apparatus including a plurality of windings, one adapted to have current induced therein by any one of the remaining windings for operating said circuit-breaker, said remaining windings being insulated from each other and each connected to a main of the system.

14. A system of alternating-current distribution having three mains arranged on different sides of the system and differing in phase by one-third of a period, and an electrosensitive device, apparatus governing said device and including a core having insulated windings thereon so proportioned that in normal operation no field is set up in said core, each main of the system including one of said windings.

15. A system of alternating-current distribution having three mains arranged on different sides of the system and differing in phase by one-third of a period, an electrosensitive device, apparatus governing said device including inducing-windings each in a main of the system, and a secondary circuit having a winding in transformer relation with each of the inducing-windings and supplying current to said electrosensitive device, said inducing-windings being insulated from each other and so proportioned that normally no magnetic field is set up by them.

16. A system of alternating-current distribution having mains on different sides of the system differing from each other in phase, an electrosensitive device, apparatus governing said device including inducing-windings insulated from each other, each main of the system including one of said inducing-windings, and a secondary circuit having a single winding in transformer relation with all of the inducing-windings and supplying current to said electrosensitive device, said inducing-windings being insulated from each other and so proportioned that normally no magnetic field is set up by them.

17. In combination, a source of polyphase current, inducing-windings connected thereto and normally producing no flux of any kind by reason of their currents differing in phase, and the windings being so wound in balance that the currents neutralize each other as far as inducing action of the windings is concerned, a secondary winding in which current is induced when the inducing-windings jointly

produce flux, and an electrosensitive device operated by said secondary winding substantially as described.

18. In combination, a three-phase generator, three insulated main conductors connected thereto so as to differ in phase by one-third of a period, a magnetic core, said main conductors being so wound upon said core that under normal conditions the integrated sum, algebraically, of all of the vectors in such portions of the mains as are wound upon said core remain substantially at zero, and an electrosensitive device adapted to be influenced by said core when the same is energized.

In witness whereof I have hereunto subscribed my name in the presence of two witnesses.

GEORGE N. EASTMAN.

Witnesses:
HOWARD M. COX,
M. C. HUTCHINGS.