H. S. OSBORNE.

INDUCTIVE INTERFERENCE SUPPRESSION DEVICE.

APPLICATION FILED AUG. 3, 1920.

1,422,470. **Patented July 11, 1922.**

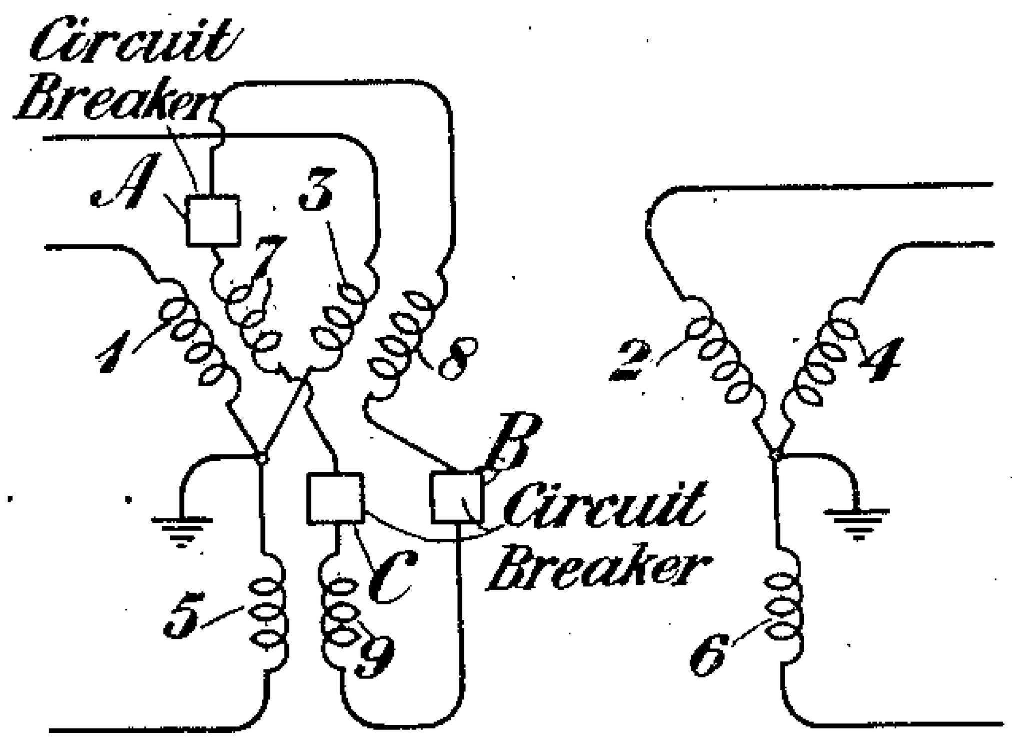

Fig. 1

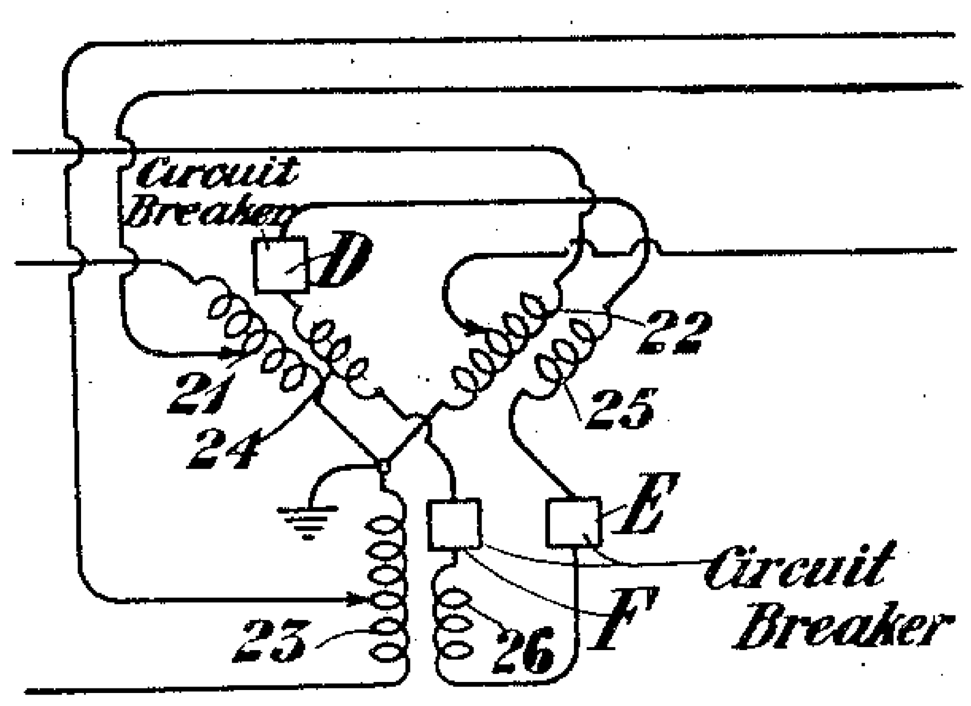

Fig. 4

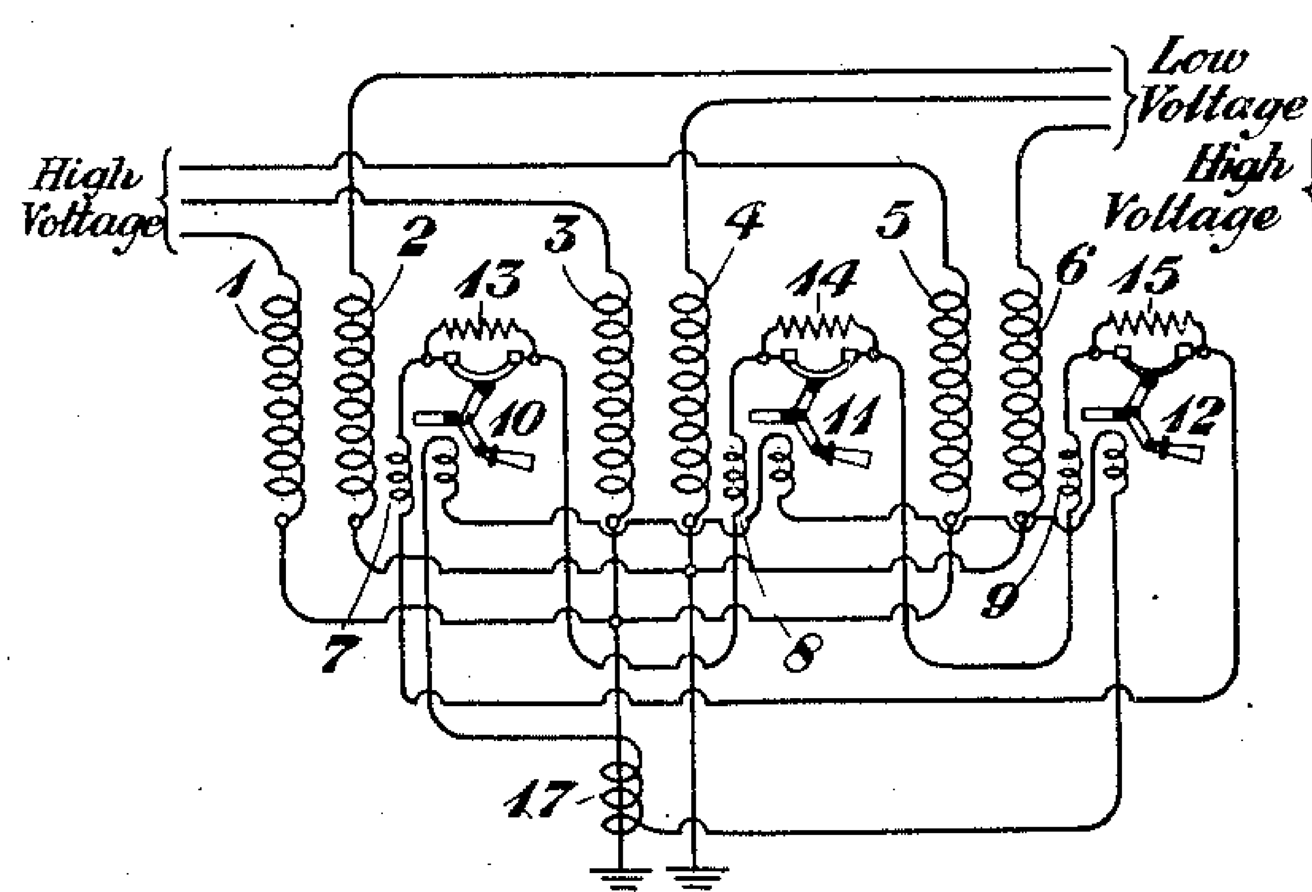

Fig. 2

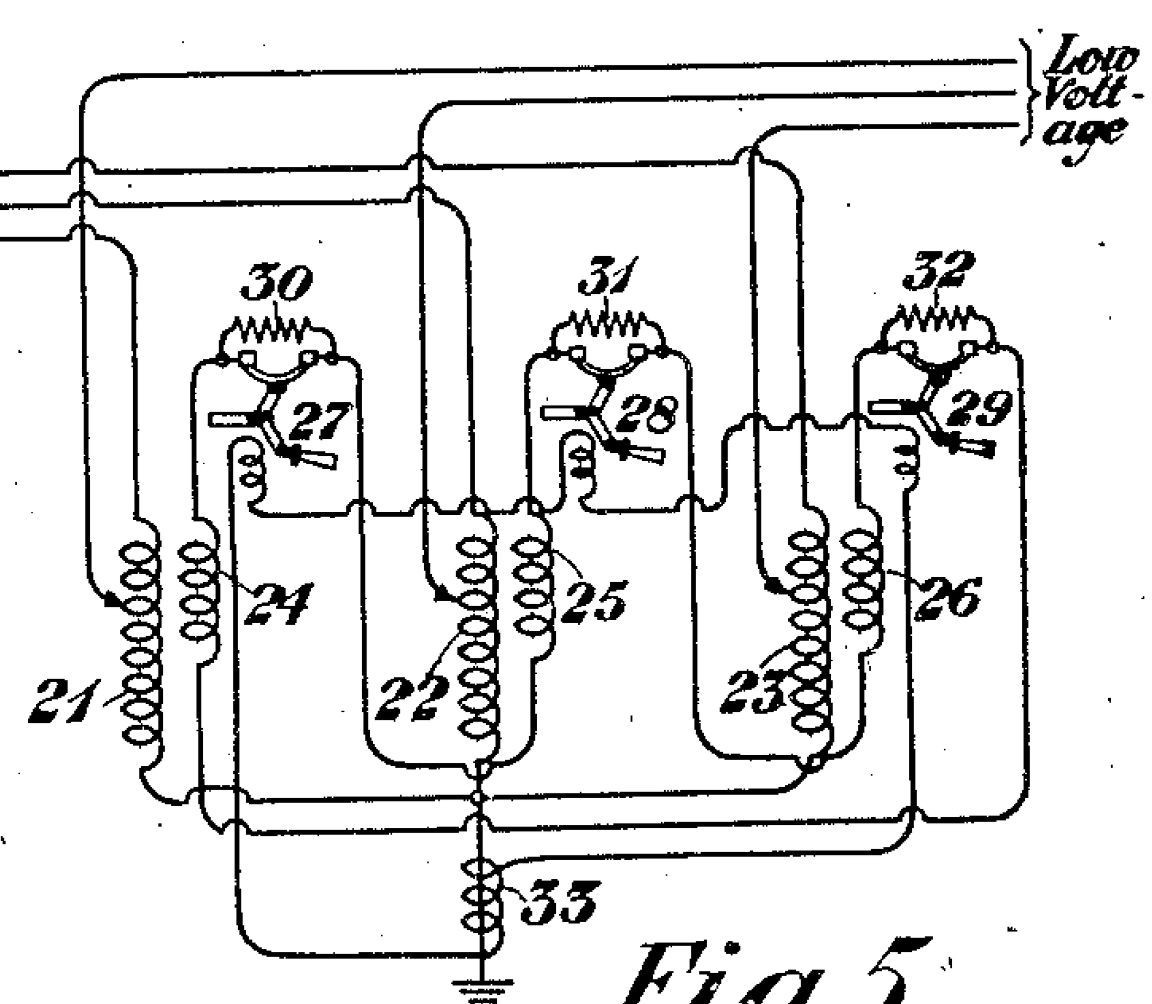

Fig. 5

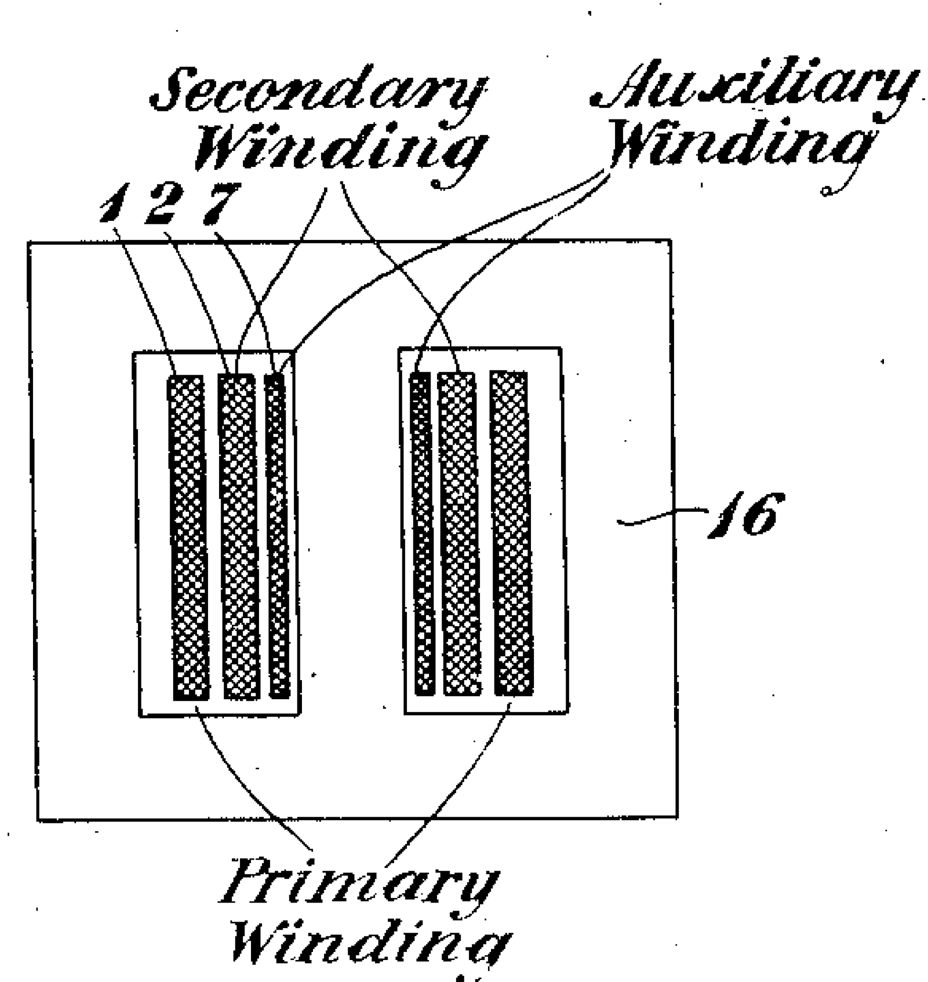

Fig. 3

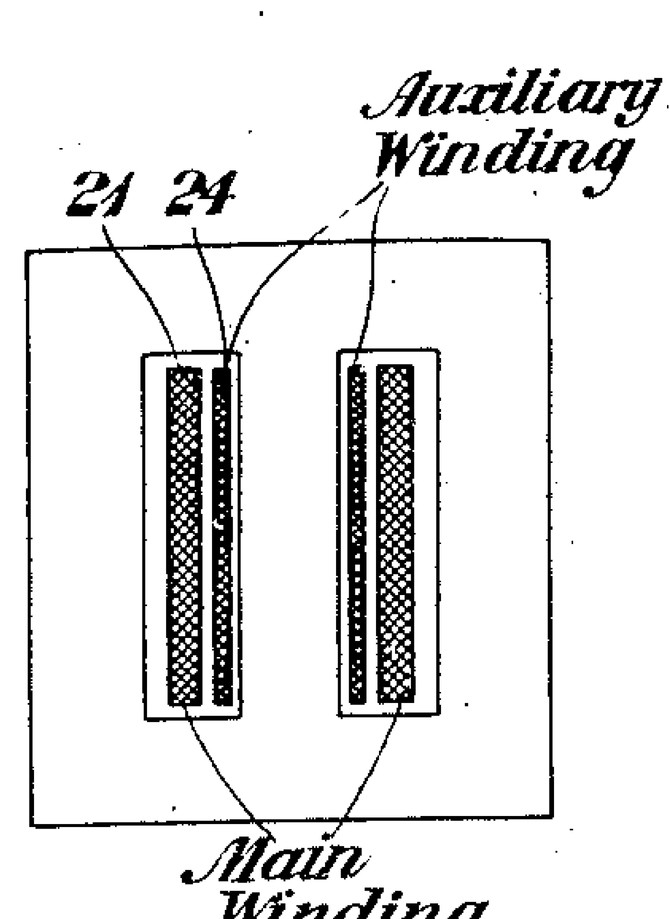

Fig. 6

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INDUCTIVE-INTERFERENCE-SUPPRESSION DEVICE.

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To all whom it may concern:

Be it known that I, HAROLD S. OSBORNE, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Inductive-Interference-Suppression Devices, of which the following is a specification.

This invention relates to devices for preventing inductive interference between high voltage power lines and signaling circuits, and especially to means applicable to power transformers adapted to substantially suppress harmonics of the fundamental power frequency, which are liable to be created by the transformers ordinarily used on such circuits.

It is customary at the present time to operate high voltage power lines with the high potential transformer windings star-connected and with the neutral point of these windings grounded. This arrangement of the transformer windings has an inherent disadvantage in that certain harmonics of the transformer magnetizing current, namely the third, ninth and fifteenth, etc., flow through the ground connection and cause relatively large inductive effects upon signaling circuits adjacent to such power lines. Experience has shown that the amount of current flowing to the ground is greatly decreased when the low voltage-windings of the transformer are delta-connected. When it is important to have both the high voltage and the low voltage windings star-connected, it has long been recognized that similar reduction in the flow of the harmonic currents can be produced if the transformer be provided with a low impedance auxiliary winding, which would be delta-connected.

In order to obtain a tertiary delta winding having sufficiently low impedance, it has been the usual practice to provide windings having a kilo-volt ampere capacity nearly as great as that of the main windings. This results in a considerable increase in the cost of the transformers. In designing transformers, it is well known that the leakage impedance of one winding may be made materially less than that of another by placing it nearer the core of the transformer. Consequently, by placing the tertiary winding adjacent to the core, a delta circuit of low impedance and small K. V. A. capacity may be obtained.

It is the object of this invention to suppress the harmonics set up in such transformers by inserting therein auxiliary windings constructed as above, so as to have low leakage reactance and relatively low K. V. A. capacity, and providing protective means to prevent injury to such auxiliary windings in case an excessive current flows through the main windings of such transformers.

This invention will be better understood from the following description when read in connection with the attached drawing, of which Figure 1 shows schematically the application of this invention to a three-phase transformer arrangement having both windings star-connected. Fig. 2 shows, in greater detail, the relative arrangement of the windings and also the protective device. Fig. 3 shows the relative arrangement of the coils of a transformer. Figs. 4, 5 and 6 show similar arrangements applied to an auto-transformer.

In Figure 1, 1, 3 and 5 represent primary windings of, for example, separate transformers which are star-connected, having the neutral point grounded, and 2, 4 and 6 represent secondary windings corresponding to the primary windings of the same transformers. Associated with the said primary and secondary windings are the auxiliary windings 7, 8 and 9 which are delta-connected and which have connected in circuit therewith protective devices A, B and C, which are designed to open the delta-connection when the circulating current in this winding reaches such magnitude as to tend to overheat the winding.

In Fig. 2, in which corresponding parts have been given the same numbers, are shown the primary and secondary windings and also the auxiliary windings referred to in Fig. 1. The protective devices A, B and C embrace respectively the circuit breakers 10, 11 and 12, which are designed to operate at a predetermined overload and to give effect to the resistance elements 13, 14 and 15, in order to limit the current which circulates on the auxiliary delta winding. It is to be understood that a single resistance could be inserted in the circuit of the auxiliary windings at one corner only of the delta-connection, but in order to minimize the voltage stresses in the delta-windings, it may be preferable to insert such resistances at the three corners of the delta, and to adjust the circuit breakers so that the said resistances may be simultaneously connected in the said circuit. These resistance elements 13, 14 and 15 may be shunted by the negligible resistance path through the circuit breakers as shown in Fig. 2, or they may be arranged so as to be connected into the circuit upon the opening of the said circuit breakers.

Fig. 3 shows a preferable arrangement of the windings of one of the transformers upon the core. In this figure the auxiliary winding 7, which is preferably a very thin cylinder, is located nearest the core, and the secondary winding 2 and the primary winding 1 are more remotely located, the secondary winding being nearer the core than the primary winding. With such an arrangement of the windings, it is possible to build an auxiliary winding of low K. V. A. capacity having relatively low impedance. Since this winding is to be delta-connected and to be used primarily for reducing the flow of the said harmonic currents, it is desirable that a relatively small amount of copper be used in the construction of the winding. The reduction in the amount of copper used would tend to increase the resistance of the auxiliary circuit, but this is substantially neutralized by the lower leakage reactance that this winding possesses, due to its being in close proximity to the core of the transformer. Because of the relatively low K. V. A. capacity of this circuit and of the possibility of a burn-out in case of an overload upon the line circuit, the special protective arrangements heretofore referred to have been provided.

Figs. 4, 5 and 6 relate to the application of an auxiliary winding to an auto-transformer. In Fig. 4, 21, 22 and 23 represent the windings of three auto-transformers which are star-connected and have the neutral points grounded. Associated with the windings 21, 22 and 23 are the auxiliaries 24, 25 and 26 respectively, which are delta-connected and have in the circuit the protective devices D, E and F which are similar to the devices A, B and C described in connection with Fig. 1.

In Fig. 5 similar parts are given the corresponding designating symbols. The devices D, E and F comprise respectively the circuit breakers 27, 28 and 29 and the resistance elements 30, 31 and 32, which are connected in the auxiliary circuit in the same manner in which the corresponding devices shown in Fig. 2 are connected.

Fig. 6 shows an arrangement of the coils upon the core of a transformer, the auxiliary winding 24 occupying the position nearer the core of the transformer, and the main winding 21 of the transformer occupying a position outside the auxiliary winding.

Having in mind the foregoing description of the various circuit arrangements and parts of the apparatus, this invention will be more clearly understood from the following description of its mode of operation.

Let it be assumed that a voltage wave of sinusoidal form is impressed upon the high voltage windings of the transformer arrangement shown, for example, in Fig. 2. It is well known that the form of the wave of the magnetizing current resulting from impressing a sine wave of voltage upon a transformer is non-sinusoidal in shape, and an analysis of this wave shows that it is made up principally of the fundamental and the third, fifth, seventh, ninth, etc., harmonics. When the three transformers are connected in star with grounded neutral, the third, ninth, etc., harmonics are in time-phase in the three transformers and currents of these frequencies tend to flow from the lines to ground through the neutral ground connection. Experience has shown that if auxiliary windings be placed on the core of the transformers, preferably adjacent to the said core, and all of the auxiliary windings of the three transformers be delta-connected, the said third, ninth, etc., harmonics of the magnetizing current will flow mainly in the closed delta circuit of the auxiliary windings and a relatively small amount will flow through the high voltage windings of the transformer to ground.

By making the impedance of the auxiliary windings of the delta circuit low, the greater part of the third harmonic currents will flow therethrough, thereby minimizing the flow through the high tension windings to ground, and thus greatly reducing the effects upon the adjacent signaling circuits that such harmonics of the magnetizing current would produce were such auxiliary winding not used. It is well known that a winding of low leakage reactance and relatively small current carrying capacity may be obtained by placing the coil, preferably cylindrical in form, adjacent to the core of the transformer. While this results in a winding of increased ohmic resistance, it is permissible, since for any given value of impedance, the resistance may be increased provided the reactance is decreased.

Because of the low current capacity of the coil it is liable to injury from a burn-out in case an excessive current is induced therein as the result of a short-circuit of one of the other windings of the transformer. Such a possibility is guarded against by the insertion in the delta winding of one or more protective devices which are designed to operate upon the flow of current of a predetermined magnitude. It is desirable, however, that the circuit-opening device, such as a circuit breaker, in opening the circuit, shall insert a resistance in the path of the delta circulating currents rather than create an open circuit, since such an arrangement avoids the creation of a high reactance between the line wires and ground. Such resistance may be inserted at one corner of the delta, or in order to minimize the voltage stresses in the delta windings, it may be preferable to insert resistances simultaneously in each of the three corners of the delta. Thus in Figs. 2 and 5, I have shown the resistances normally connected into the circuit but shunted by the low resistance paths through the circuit breakers. Upon the opening of the said circuit breakers, the resistances are effectively connected into the circuit and thereby avoid the creation of the high reactance heretofore referred to. Whenever the current flowing to ground from the neutral connection of the high voltage windings exceeds a certain predetermined value, the circuit breakers 10, 11 and 12 of Fig. 2 and the corresponding breakers of Fig. 5 will be operated as a result of the current induced in the current transformer 17.

Although this invention has been disclosed as having a particular form and embodiment of parts, it is to be understood that it is capable of embodiment in other forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a power transmission system, the combination of a high tension circuit, a low tension circuit, a transformer having main and auxiliary windings, the said main windings being star-connected with a conductor from each neutral point to ground and the said auxiliary windings being delta-connected with a protective device connected therewith, to limit the current in said auxiliary windings, and means connected with the ground conductor from the neutral point of the primary windings to operate said protective device when the current in the ground conductor reaches a certain predetermined value.

2. In a power transmission system, the combination with a group of transformers arranged for three-phase transmission, of three-phase primary and secondary circuits connected therewith, the said transformers having main and auxiliary windings, the main windings being star-connected with a conductor to ground from the neutral point of the primary windings and the said auxiliary windings being delta-connected with a protective device in series therewith, and means connected with said ground conductors to effect the opening of said delta circuit when the current flowing from the said neutral point to ground reaches a predetermined value.

3. In a power transmission system, the combination with a group of transformers arranged for three-phase transmission, of three-phase circuits connected therewith, the said transformers having main and auxiliary windings, the main windings being star-connected with grounded neutral, and the said auxiliary windings being delta-connected with a protective device adapted to effectively connect a current limiting resistance into said delta circuit when the current flowing from the said neutral point to ground reaches a predetermined value.

4. In a power transmission system, the combination with a group of transformers arranged for three-phase transmission, of three-phase circuits connected therewith, the said transformers having main and auxiliary windings, the main windings being star-connected with grounded neutral, and the said auxiliary windings being delta-connected, having a resistance element in series therewith normally shunted by a low resistance path of a circuit breaker and adapted to be effectively connected into the said circuit by the operation of the said circuit breaker when the current flowing from the said neutral point to ground reaches a predetermined value.

5. In a power transmission system, the combination with a group of transformers arranged for three-phase transmission, of three-phase circuits connected therewith, the said transformers having main and auxiliary windings, the main windings being star-connected with grounded neutral, and the said auxiliary windings being delta connected, having resistance elements in series therewith in each corner of said delta-connection, the said resistances being normally shunted by a circuit breaker and adapted to be effectively connected into the said circuit by the operation of the said circuit breaker when the current flow between the said neutral point and ground reaches a predetermined value.

6. In a transformer, the combination, with a core, of a main winding and an auxiliary winding, the said auxiliary winding comprising a thin cylindrical coil adjacent to the core, whereby the leakage reactance component of the impedance of said winding, may be made small relative to its resistance component, and protective means to prevent over-heating said auxiliary winding due to excess current flowing therethrough.

7. In a power transmission system, the combination with a high tension circuit of a low tension circuit, a group of star connected windings individual to the high tension and the low tension circuits and having the neutral points connected to ground, a group of delta connected windings having connected in series therewith current limiting means normally shunted by a low resistance path, and means controlled by the current flow through the conductor between one of said neutral points and ground to

open the said low resistance path, thereby rendering the current limiting means effective.

8. In a power transmission system, the combination with a group of transformers arranged for three-phase transmission, of three-phase primary and secondary circuits connected therewith, the said transformers having main and auxiliary windings, the main windings being star connected with grounded neutral points and the said auxiliary windings being delta connected and having arranged in series therewith current limiting means normally shunted by the low resistance path through a circuit breaker which is controlled by the current flow through the ground connection between one of the said neutral points and ground.

9. In a multiphase electrical transformer, the combination with star-connected primary windings of star-connected secondary windings, means to connect the neutral point of the primary windings to ground, delta-connected auxiliary windings inductively connected to said primary and secondary windings, switching means connected with said auxiliary windings, and means connected with the ground conductor from the neutral point of the said primary windings to effect the operation of the said switching means when the said current reaches a predetermined value.

In testimony whereof, I have signed my name to this specification this 31st day of July, 1920.

HAROLD S. OSBORNE.