Sept. 27, 1927. 1,643,350

R. A. SHETZLINE

NEUTRALIZATION OF INDUCTIVE INTERFERENCE

Filed July 1, 1924 2 Sheets-Sheet 1

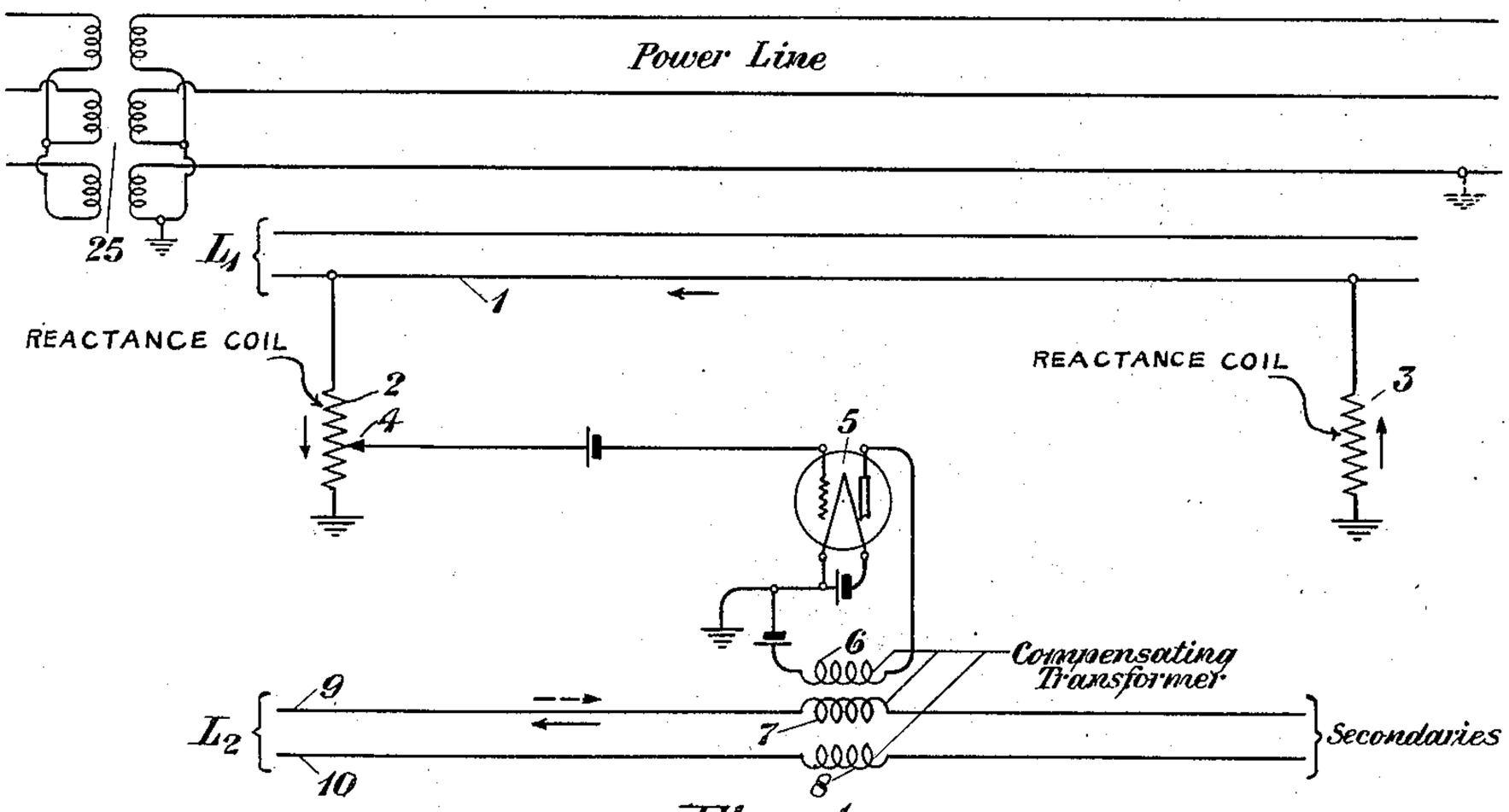

Fig. 1

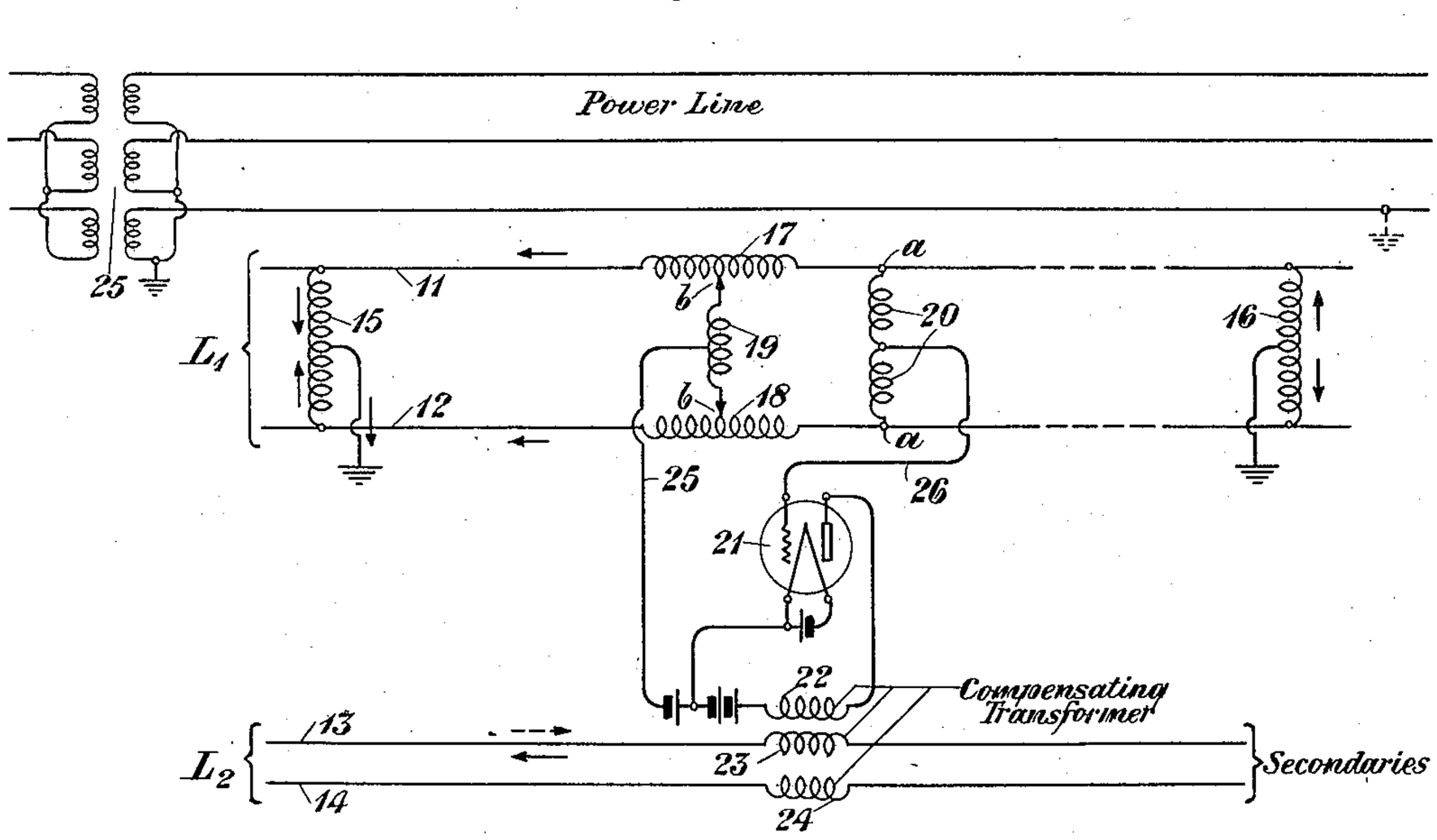

Fig. 2

INVENTOR
R. A. Shetzline
BY
ATTORNEY

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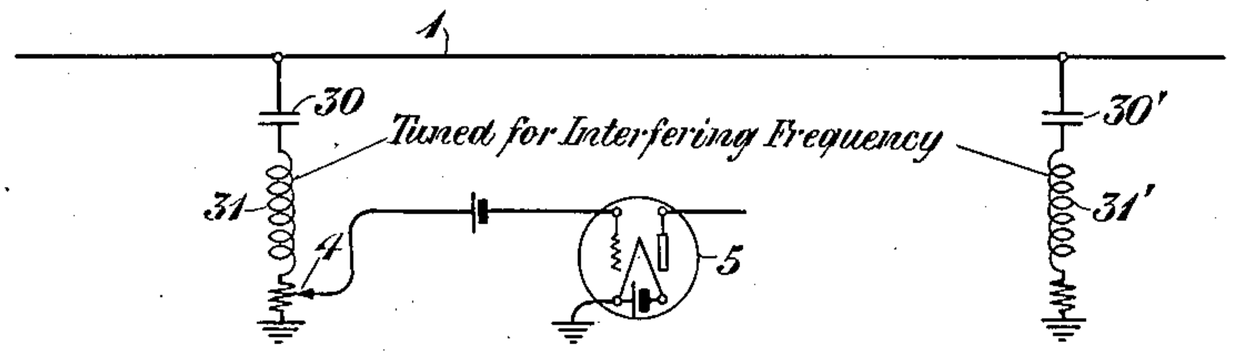

Fig. 1a

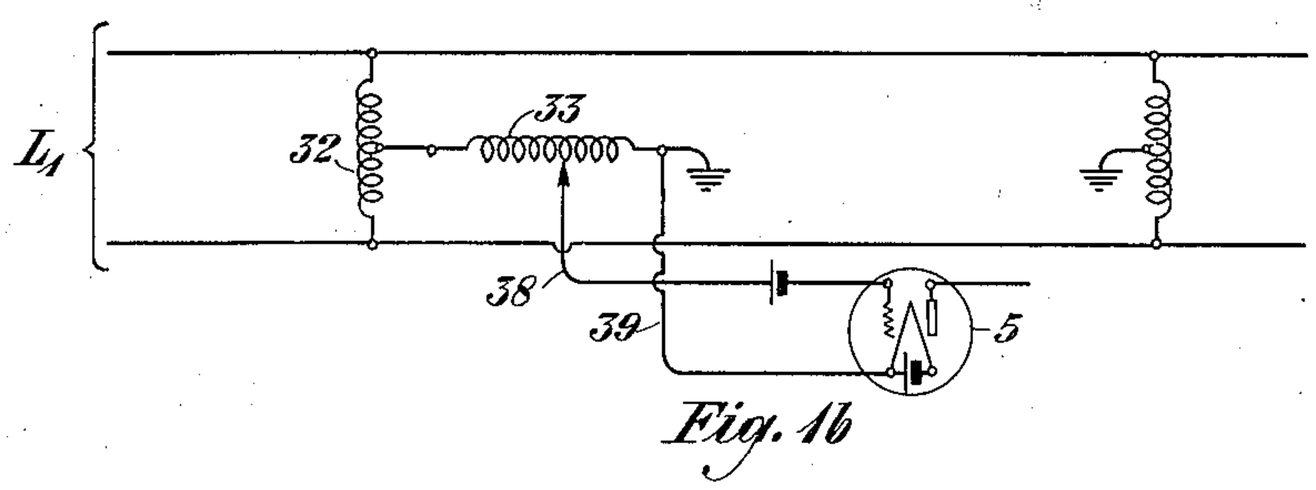

Fig. 1b

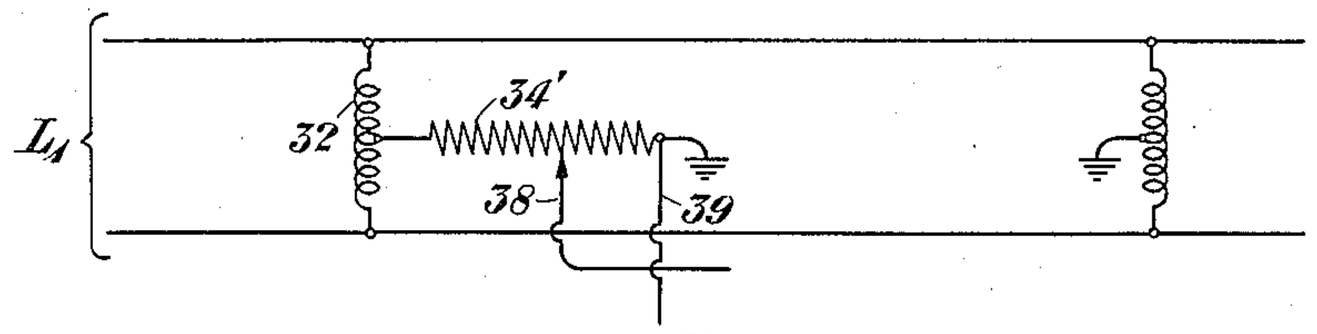

Fig. 1c

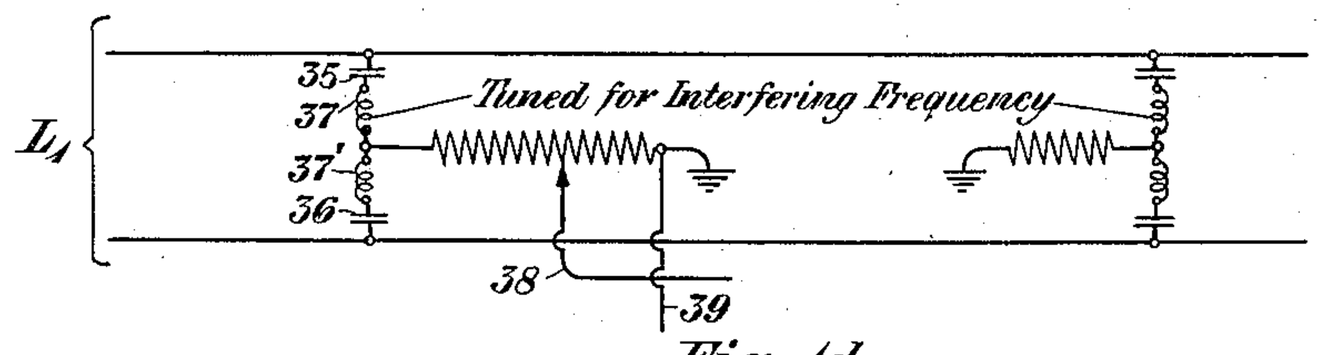

Fig. 1d

INVENTOR
R. A. Shetzline
BY
ATTORNEY

Patented Sept. 27, 1927. 1,643,350

UNITED STATES PATENT OFFICE.

ROY A. SHETZLINE, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

NEUTRALIZATION OF INDUCTIVE INTERFERENCE.

Application filed July 1, 1924. Serial No. 723,583.

This invention relates to the neutralization of interference, and particularly to a method and means for the neutralization of interfering potentials that may be set up in signaling or communication circuits by adjacent power, railway or lighting circuits, or by any cause extraneous to the circuits themselves.

When communication or signaling circuits are exposed to power, lighting or other foreign circuits, interfering potentials are set up in the communication circuits. Unless such interfering potentials are neutralized, they interfere with the reception of signals transmitted over the communication circuits, the degree of interference depending upon the relative magnitudes of the two currents. Furthermore, the interference may take other forms, such as an actual breakdown of some part of the communication circuits.

Various means have been devised and used for the neutralization of interfering potentials. One form of such interference reduction means which is commonly known as a compensating transformer is disclosed in the patent to J. A. Barrett, No. 940,658, dated November 23, 1909. Such compensating transformers are multiple-winding transformers in which a certain proportion of the windings are used as primaries and the remainder as secondaries. The primary windings are connected with certain conductors of a group of the communication conductors, in which an interfering potential is set up by a source extraneous to the communication circuits. Similarly, each secondary winding is connected with one of the remaining conductors of the communication circuits, which also have an interfering potential created in them. The windings are so poled that the current flowing through the primary windings will induce a potential serially in the secondary windings, which is substantially equal and opposite in phase to the interfering potential set up in each of the conductors connected with the said secondary windings. To obtain this substantial equality of potential requires the use of sufficient primary conductors to provide the required magnetizing current without excessive impedance drop. In order to provide a circuit for the flow of this magnetizing current, the primary conductors are grounded, either directly or through suitable impedances, at suitably chosen points outside of or near the ends of the exposed section of the communication circuits. Since these so-called primary circuits contain the primary windings of the neutralizing transformers, which windings are so arranged that when currents flow through all of them in the same direction a cumulative effect is produced in the secondary windings, these circuits cannot be used for grounded telegraph purposes. Since it is common practice to use long communication circuits for both telephone and telegraph purposes, it will be apparent that the sacrificing of any of the telegraph circuits means a corresponding reduction in the service efficiency of such circuits. In practice, the number of primary conductors necessary for the neutralization of interference is a relatively large fraction of the total number of conductors, because the efficiency of neutralization requires the impedance external to the primary transformer winding to be small compared with that of the winding itself.

This invention consists in the provision of a method and means whereby a high efficiency of neutralization may be effected through the use of relatively few primary conductors.

Other and further objects of this invention will be apparent from the following description, when read in connection with the attached drawing, of which Figure 1 shows a simple form of embodiment of the invention; Figs. 1[a] to 1[d] show other methods of connecting the amplifying apparatus of Fig. 1 to the primary circuit; and Fig. 2 shows another form of neutralizing arrangement.

In Fig. 1 the source of disturbing potential is, for the purpose of illustrating and describing this invention, represented as a power line connected by the transformer 25 with some form of generating device. L_1 and L_2 represent two communication circuits in which interfering potentials are set up by the power line. Conductor 1 of line L_1 represents a primary circuit of the neutralizing system. Connected between conductor 1 and ground at or near the ends of the exposure to the power line are the high reactances 2 and 3, which reactances are preferably sufficiently high so as not to unbalance seriously the circuit L_1, and thus impair its usefulness for telephone purposes.

The reactance 2 is variably connected by contact 4 with the vacuum tube amplifier 5, so that the potential applied to the grid of the tube may be controlled. The primary winding 6 of the compensating transformer is connected with the plate-filament circuit of this tube. Secondary windings 7 and 8 of this transformer are connected with the conductors 9 and 10 of the line L_2. It is to be understood that although only one secondary communication circuit is shown, the number that may be cared for by this invention is not so limited, inasmuch as the neutralizing capacity of the apparatus may be varied to care for any number of circuits. The windings 7 and 8 are poled with respect to 6, so that the potentials set up in 7 and 8 by the current flow through 6 will oppose the interfering potentials in conductors 9 and 10 of line L_2.

The manner in which the system of Fig. 1 operates is as follows:

When a field is set up by currents flowing over the conductors of the power line, as, for example, by current from transformer 25, to a fault upon one of the conductors (such as the ground represented by dotted lines in the figure), and thence returning through the earth, potentials will be set up in the conductors of the signaling circuits L_1 and L_2. These potentials will tend to produce a flow of current over the conductors of the said circuits, which, as is well known, will be detrimental to the signals transmitted, as, for example, by interference with the telegraph signals carried by the superimposed telegraph circuits.

Since conductor 1 of circuit L_1 is grounded at the points shown, a flow of induced current will result, which, for example, may be assumed to be in the direction represented by the solid arrows. Furthermore, interfering potentials will be created in conductors 9 and 10 which would tend to cause a flow of current in each conductor, which may be assumed to be in the direction represented by the solid arrow. The flow of current through the resistance 2 will cause a potential difference across the said resistance, any portion of which potential may be applied to the grid of the vacuum tube amplifier 5. The potential applied to the grid controls the output current of the tube, namely, that flowing through the plate-filament circuit which includes the primary winding 6 of the compensating transformer. The windings, 6, 7 and 8 are so arranged that the potentials induced across windings 7 and 8 by the output current of the amplifier will cause a potential in each of the conductors 9 and 10 which will be opposite to those set up therein by the source of interference, viz, the power line. By proper adjustment of the contact 4 of the resistance 2, the interfering potentials in the conductors of L_2, and in other circuits similar to L_2 connected with windings similar to 7 and 8 may be substantially neutralized.

Other modes of connecting the amplifying and compensating apparatus between the primary and secondary circuit or circuits are shown in Figs. 1^a to 1^d. The arrangement shown in Fig. 1^a is similar to that shown in Fig. 1 in that one conductor only of the primary signaling circuit is utilized for the purpose of supplying the neutralizing potential to the amplifier. Each ground connection shown in Fig. 1^a includes a condenser 30 and an inductance 31 which have such values that the circuit with which they are connected will be tuned for the interfering frequency. By this arrangement, voltages between the primary conductor and ground, the frequencies of which are sufficiently lower than that of the induced interfering voltage, would be excluded from the inductance element of the ground connection, so that the magnetizing current will be substantially free from components of these frequencies. The value or this arrangement lies in its ability to prevent cross-fire between telegraph circuits connected with secondaries of a common neutralizing transformer. For example, if we tune the primary circuit for currents of 25 or 60 cycles, which are the frequencies usually found in railway or power interference, these currents will flow over the grounded circuit, but currents of telegraph frequencies of the order of 12 to 15 cycles could be transmitted over conductor 1 without causing sufficient corresponding magnetizing current to produce cross-fire in the telegraph circuits operated over conductors 9 and 10.

Since the grounding of one of the conductors of a circuit transmitting telephone currents tends to unbalance the circuit, it may be preferable to connect the amplifying and compensating apparatus shown in Fig. 1^a with the primary signaling circuit in a manner which does not involve an unsymmetrical grounding of that circuit. Figs. 1^b to 1^d show various ways in which this may be acomplished. In each of these figures the bridged impedances between the conductors of the circuit L_1 are of such value that their shunting effect upon telephone currents is insignificant. In Fig. 1^b, the midpoint of the bridged reactance 32 is connected to ground by a reactance 33, having a contact whose position may be adjusted. The potential drop across part of this resistance is applied to the input circuit of the amplifier 5. The arrangement shown in Fig. 1^c differs structurally in that a high resistance 34′ replaces the reactance 33 of Fig. 1^b. The arrangements shown in Fig. 1^d embodies the idea of tuning the primary circuit for the interfering frequency, which idea was de-

scribed above in connection with Fig. 1a. In Fig. 1d the potential applied to the input circuit of the amplifier is derived from the drop across a portion of a low resistance connected between the junction of the inductances 37 and 37′ and ground.

In the arrangement shown in Fig. 2, the circuit L_1 of the communication system constitutes the primary or controlling circuit of the neutralization system and the circuit L_2, comprising conductors 13 and 14, represents a secondary circuit in which interfering potentials are to be neutralized. As stated in connection with the description of Fig. 1, there may be an indefinite number of circuits similar to L_2, in each of which the interfering potentials are neutralized in the same manner as in L_2. Bridged across the conductors 11 and 12 at the ends of the exposure to the power line are the retardation coils 15 and 16, the midpoint of each of which is connected to ground. Connected serially with conductors 11 and 12 are the impedance coils 17 and 18, which are non-inductive to currents flowing in opposite directions therethrough. These coils constitute, in effect, a potentiometer having two contacts connected by the coil 19, the midpoint of which is connected with the filament of the vacuum tube 21. Bridged across the conductors 11 and 12 at or near the place where the coils 17 and 18 are connected into the circuit L_1 is a retardation coil 20, the midpoint of which is connected with the grid of the vacuum tube 21. The plate-filament circuit of this tube contains the winding 22 of the neutralizing transformer, of which the secondary windings 23 and 24 are connected with the conductors 13 and 14, respectively, of the line L_2. The manner in which this arrangement functions is as follows: When a field is set up by current flowing over the wires of the power line, current will flow over conductors 11 and 12 and through the ground, the direction of which may, for example, be represented by the solid arrow. The flow of the disturbing currents through the coils 17 and 18 will create a difference of potential across them. The potential between the points "*a*" where the coil 20 is connected with the said conductors and the points "*b*" upon the coils 17 and 18, at which the contacts, connected with the coil 19, may be set, will be applied to the grid of the vacuum tube 21 and will control the current flowing through the plate-filament circuit of this tube. By proper adjustment of the contact points upon the coils 17 and 18, the current through the winding 22 may be made of such value as to induce in windings 23 and 24 of the compensating transformer potentials which will substantially neutralize the interfering potentials created in conductors 13 and 14 of the communication circuit L_2.

While mention has been made of the use of these neutralizing devices in the signaling circuits at the ends of the exposure to the power lines, or other sources of interference, it is desirable to point out that the invention is not limited in use to those particular points. It may be found desirable to use a plurality of neutralizing arrangements, such as have been described, at a plurality of intermediate points. With such an arrangement, the interfering potentials which a single neutralizing device would have to neutralize would be of smaller magnitude than the accumulated interfering potential of the entire exposed section, and the occurrence of unduly high voltages to ground would be avoided.

Although this invention has been disclosed as embodied in particular forms, it is apparent that it is not so limited but is capable of embodiment in other forms without departing from the spirit and scope of the appended claims. In particular, it is to be understood that the vacuum tube amplifying means shown in the drawings are schematic and that additional or different means known to those skilled in the art, such as additional tubes in cascade or in parallel arrangement, may be used.

What is claimed is:

1. In an interference neutralizing system, the combination with a source of interfering potential of a plurality of circuits having potentials created therein by the said source, an impedance connected between one conductor of one of said disturbed circuits and ground at a plurality of points in the section exposed to the said source of interfering potential, an amplifier having its input side variably connected with one of said impedances, a compensating transformer having its primary winding connected with the output side of the said amplifier and having its secondary windings connected with the conductors of the other of said disturbed circuits.

2. In an interference neutralizing system, the combination with a source of interfering potential of a plurality of circuits each arranged for the simultaneous transmission of metallic telephone and grounded telegraph currents, an impedance connected between one conductor of one of said circuits and ground at a plurality of points in the exposed section, the value of the said impedance being high, an amplifier having its input side connected with one of the said impedances, a compensating transformer having its primary winding connected with the output side of the said amplifier and having its secondary windings connected with the conductors of the other of said disturbed circuits.

3. In an interference neutralizing system, the combination with a source of interfering

potential of a fixed frequency, of a plurality of circuits having potentials created therein by the said source, a plurality of impedances connected between a conductor and ground of one of said circuits, the constants of the said impedances being so chosen as to tune the intervening section of conductor to the interfering frequency, an amplifier controlled by the potential across one of said impedances, and means to impress a resultant neutralizing potential upon the conductors of the other of said circuits.

4. In an interference neutralizing system, the combination with a plurality of conductors in which an interfering potential of fixed frequency has been created by a source external to the plurality of conductors, means to connect one conductor to ground at a plurality of points and to tune the intervening section to the interference frequency, and neutralizing means connected with one of said grounding means and having means to apply a potential to the other of said conductors to neutralize the interfering potential.

In testimony whereof, I have signed my name to this specification this 30th day of June, 1924.

ROY A. SHETZLINE.