April 5, 1949. H. E. WEAVER 2,466,629

NEUTRALIZING SYSTEM AND METHOD

Filed Dec. 15, 1945 2 Sheets-Sheet 1

Fig. 1.

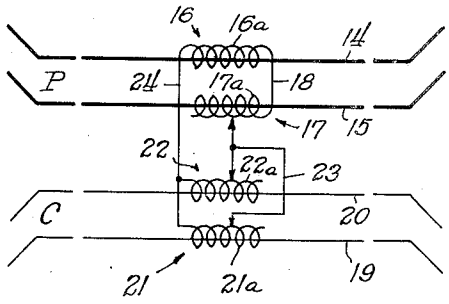


Fig. 2.

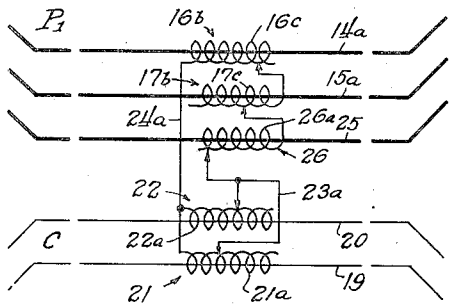


Fig. 3.

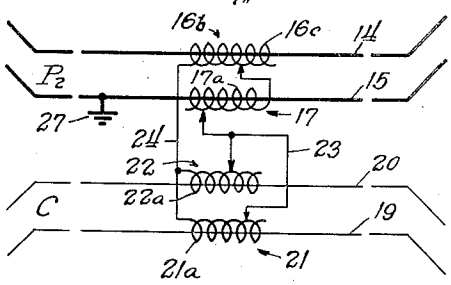


Fig. 4.

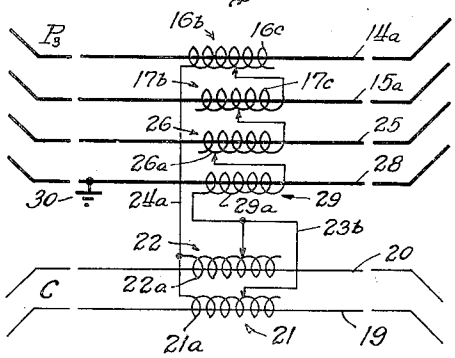


Fig. 5.

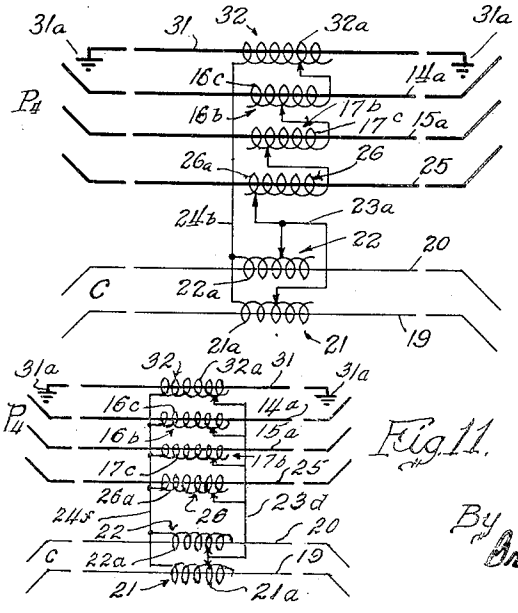


Fig. 6.

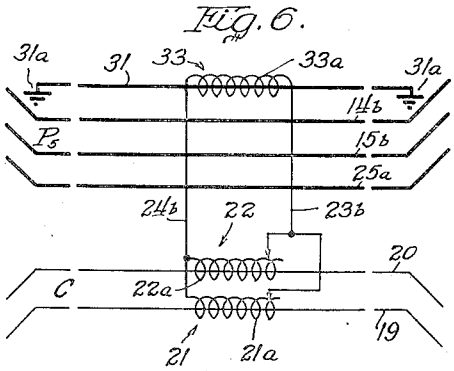


Fig 11.

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NEUTRALIZING SYSTEM AND METHOD

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Fig. 7.

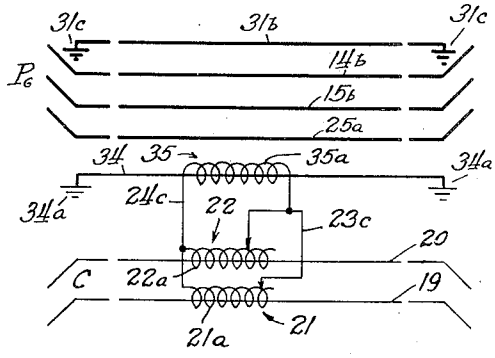


Fig. 8.

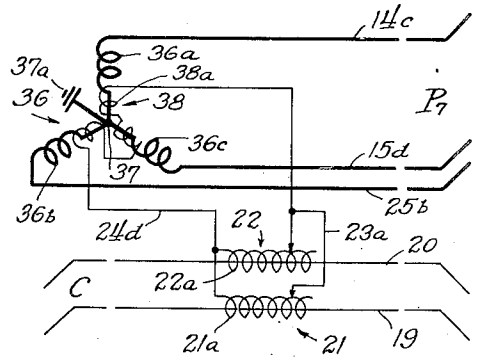


Fig. 9.

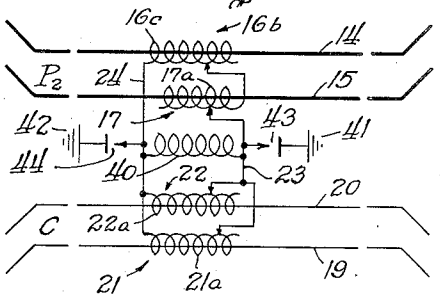
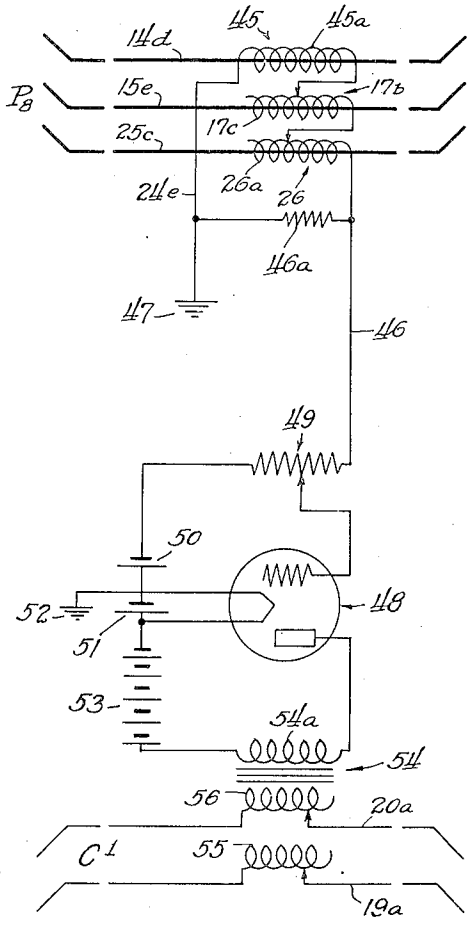


Fig. 10.



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UNITED STATES PATENT OFFICE

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NEUTRALIZING SYSTEM AND METHOD

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Application December 15, 1945, Serial No. 635,377

10 Claims. (Cl. 171—97)

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This invention relates to neutralizing systems, and has to do with a system for, and method of, neutralizing induction in communication lines paralleling power lines.

It frequently is necessary for communication lines, such as telephone, telegraph, railway signal and other signal lines, not used primarily for transmitting power, to parallel closely alternating current power transmission lines for considerable distances. The inductive effect of the power line on the communication line, at such parallels, causes objectionable interference in the communication line, particularly in the event of an unbalanced load or a fault in the power line.

Numerous attempts have been made to prevent interference in communication lines paralleling power lines, but none of such attempts has to my knowledge provided an entirely satisfactory solution of the problem, nor succeeded in reducing the interference to such an extent as to be unobjectionable and, in present practice, considerable interference in a communication line paralleling a power line is accepted as being unavoidable. It is known to provide at a parallel a shield wire in the communication line, transformer coupled to the signal transmitting wires of that line. In such a system, the shield wire must extend the full length of the parallel and should be of low resistance and well grounded, which frequently entails considerable expense and is objectionable for that reason. If there be a number of communication lines in a parallel, each of such lines must be provided with a shield wire, with attendant increased expense. The voltage induced in the shield wire of the communication line, by the power line, can be no more than that induced in the signal transmitting wires of the communication line. The resistance in the shield wire, including the transformer and grounds thereof and the resistance of the wire itself, shifts the phase of the current induced in that wire by the power line and energy losses in the transformers are inevitable. The result is that the neutralizing voltage induced in the signal transmission wires of the communication line is less than the interfering voltage induced in such wires by the power line, and is never in completely reverse phase or 180° out of phase with the latter voltage.

It is, therefore, impossible, in the known system referred to, to completely neutralize the voltage induced in the signal transmitting wires of the communication line by the power line. It has been proposed, in such known system, to use condensers and reactances in an endeavor to bring

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the induced current in the shield wire more nearly into phase with the current induced in the signal transmission wires of the communication line by the power line. That has not been entirely successful, nor does it in any way avoid the basic difficulty referred to, namely, the fact that the voltage induced in the signal transmission wires of the communication line by the transformer coupling thereof to the shield wire is never equal to the voltage induced in such transmission wires by the power line, so that the latter voltage can never be completely neutralized even if the difficulty with respect to phase difference were completely overcome. The use of condensers and reactances does not solve the problem and adds materially to the cost of the system, which is objectionable for obvious reasons.

I have discovered that it is possible to neutralize completely voltage induced in a communication line by a power line, by applying to the communication line neutralizing voltage determined by energy derived directly from the power line in contradistinction to energy derived from a shield wire or like source included in the communication line. To that end, I provide in the power line transformer means effective to evaluate the interfering effect of that line, and introduce into the communication line, under control of such transformer means, voltages of proper phase and magnitude to neutralize the voltages induced in the communication line by the power line. The transformer means of the power line is directly coupled to the means for applying to the communication line neutralizing voltage, which latter may be accomplished by either electronic means or magnetic means, or other suitable equivalent means, though ordinarily I prefer to use magnetic means. In the latter case, the transformer means in the power line is directly coupled to neutralizing transformer means in the communication line. Since the energy derived from the power line, by the transformer means thereof, is much greater than that induced by the power line in the communication line, it is possible not only to neutralize completely the communication line, but to over neutralize it, if desired, which is advantageous in certain cases. It is not necessary in such a system to use an auxiliary wire or grounds, though they may be used if desired. When an auxiliary wire is used, it is included in the power line, with the advantages noted with respect to available neutralizing energy, and may be quite short relative to the parallel, a distinct advantage with respect to parallels of considerable

length. If there are several communication lines in a parallel, as frequently occurs, each thereof may be neutralized from the transformer means of the power line, in the manner above stated, avoiding necessity of providing a shield wire for the full length of the parallel in each communication line, as is necessary in the known system above referred to, with a corresponding saving in cost. Also, in cases where a power line and a communication line closely parallel, then separate widely and again parallel, it is possible to neutralize the communication line at both parallels by over neutralizing one of the parallels sufficiently for that purpose, thereby avoiding in many cases duplicate installations of the system of my invention with a corresponding saving in cost. Further objects and advantages of my invention will appear from the detail description.

In the drawings:

Figure 1 is a diagrammatic view of a neutralizing system embodying my invention;

Figure 2 is a diagrammatic view of a modified form of neutralizing system embodying my invention;

Figure 3 is a diagrammatic view of a second modified form of neutralizing system embodying my invention;

Figure 4 is a diagrammatic view of a third modified form of neutralizing system embodying my invention;

Figure 5 is a diagrammatic view of a fourth modified form of neutralizing system embodying my invention;

Figure 6 is a diagrammatic view of a fifth modified form of neutralizing system embodying my invention;

Figure 7 is a diagrammatic view of a sixth modified form of neutralizing system embodying my invention;

Figure 8 is a diagrammatic view of a seventh modified form of neutralizing system embodying my invention;

Figure 9 is a diagrammatic view of an eighth modified form of neutralizing system embodying my invention;

Figure 10 is a diagrammatic view of a ninth modified form of neutralizing system embodying my invention, in which the transformer means of the power line is electronically coupled to the communication line; and

Figure 11 is a diagrammatic view of a tenth modified form of neutralizing system embodying my invention.

In Figure 1 power line P parallels communication line C, the two lines being spaced a short distance apart as, for example, at opposite sides of a highway. The power line P comprises two wires or conductors 14 and 15 respectively having therein transformers 16 and 17, the latter being a variable transformer. The primaries of transformers 16 and 17 are respectively in series with wires 14 and 15, and the secondaries 16a and 17a thereof are series connected at one end by a lead 18. The communication line C comprises two signal transmission wires or conductors 19 and 20 respectively having therein variable transformers 21 and 22. The secondaries of the transformers 21 and 22 are respectively in series with the wires 19 and 20, and the primaries 21a and 22a thereof are connected in parallel with each other and respectively in series with secondaries 16a and 17a of transformers 16 and 17, by a lead 23 connecting the adjustable taps of the transformers 21 and 22 together and to the adjustable tap of secondary 17a of transformer 17,

and a lead 24 connecting the other end of secondary 16a of transformer 16 to the primaries of transformers 21 and 22.

It will be seen that, in Figure 1, the transformers in the communication line are directly coupled to the transformers in the power line. The transformers 16 and 17 measure the currents flowing in the power line wires 14 and 15, respectively, and the secondaries 16a and 17a of these transformers, being connected in series, will measure the difference between the two line currents, or the residual current. Accordingly, the current across the transformer secondaries 16a and 17a will be proportional to the residual current and gives an accurate measure or evaluation of the interfering effect of the power line. This current across the secondaries 16a and 17a is conveyed to the primaries 21a and 22a of the transformers 21 and 22, respectively, and induces in wires 19 and 20 voltage of opposite phase to the interfering voltage induced in the communication line by the power line. In that connection, the phase angle between the primary and secondary of a transformer is extremely small, so that the neutralizing voltage induced in the communication line wires is in reverse phase to the interfering voltage induced in such wires by the power line, that is, 180° out of phase with the latter voltage, or substantially so. The variable transformers are, of course, properly adjusted to assure that the neutralizing voltage is of sufficient magnitude to assure complete neutralization of the interfering voltage, ample energy being available for that purpose, since the neutralizing energy is derived directly from the power line. That renders it possible to neutralize completely interfering voltage induced in the communication line by the power line, regardless of the coupling therebetween, length of parallel, distance between the lines, and related factors.

In the above description I have referred to the use of the system of my invention with respect to a condition of unbalance in the power line, resulting from a fault in one of the power line wires, or from other cause, since interference in the communication line resulting from unbalance or residual current in the power line is the most objectionable condition ordinarily encountered. It will be understood, however, that this system is equally effective for neutralizing balanced induction in the communication line, caused by flow of balanced currents in the power line wires. While I preferably provide variable transformers in the power line or in the communication line, or in both, to facilitate proper adjustments to assure complete neutralization, that is not essential to the broader aspects of my invention, and fixed transformers of proper values may be used if desired. Also, if several communication lines be included in a parallel, each thereof may be neutralized by providing it with transformers similar to transformers 21 and 22, having their primaries connected to leads 23 and 24, extended for that purpose. Further, in cases where a power line and a communication line closely parallel, then separate widely and again parallel, by overneutralizing the communication line at one of such parallels to a proper extent it may also be neutralized at the other parallel, avoiding in many cases necessity of duplicate installations of the system of my invention, with a corresponding saving in cost. Since the neutralizing energy is derived directly from the power line, there is available ample energy for overneutralizing as and for the purpose stated. The general

system of Figure 1, with slight variations, is applicable to any single or multiphase power line with or without an ungrounded, a unigrounded, or a multigrounded neutral wire, and with or without lightning protection or ground wire; as will appear more fully presently.

In Figure 2 I have shown the neutralizing system of my invention as comprising a power line P^1 having three wires or conductors 14^a, 15^a and 25, illustrative of either a three phase, or a three wire single phase Edison, power system. The wires 14^a and 15^a have therein transformers 16^b and 17^b respectively, both variable, and wire 25 has therein a variable transformer 26. The secondaries 16^c, 17^c and 26^a of the transformers 16^b, 17^b and 26 are connected in series, secondary 16^c is connected by lead 24^a to primaries 21^a and 22^a of transformers 21 and 22 in the communication line wires 19 and 20, respectively, as before, and primaries 21^a and 22^a are connected in parallel with each other and respectively in series with the secondaries of the power line transformers. The power line transformers evaluate the interfering effect of that line and, by means of the directly coupled transformers in the communication line, apply to the wires of the latter line voltage of proper phase and magnitude to neutralize completely interfering voltage induced in the communication line by the power line. In referring to complete neutralization of the communication line, I mean that it is complete from a practical standpoint in that any objectionable interference in the communication line by induction from the power line is eliminated, though it may not be theoretically complete. However, if an extremely high degree of neutralization is desired and the power line P^1 is a three phase line, the phase angle of the neutralizing voltage may be shifted, by adjusting the turns of the series transformer of the proper phase of the power line, so that the neutralizing voltage is completely in reverse phase to, or 180° out of phase with, the interfering voltage induced in the communication line by the power line. That assures theoretically as was as practically complete neutralization of the communication line.

The system shown in Figure 3 is substantially the same at that of Figure 1, except that the transformer 16^b in the power line P^2 wire 14 is variable, and the power line P^2 is unigrounded, wire 15 thereof being grounded at 27. The transformers in the power line evaluate the disturbing influences in that line arising from steady current flow, stray currents, unbalance due to a fault to ground of one of the power line wires, or other causes, such as would induce interfering voltages in the communication line, and, through their direct coupling to the transformers in the latter line, apply to that line voltages of proper phase and magnitude to effect practically complete neutralization thereof.

Figure 4 shows a neutralizing system embodying my invention applied to a parallel comprising a unigrounded three phase power line. The arrangement is similar to that of Figure 2, except that the power line P^3 includes a fourth wire 28 having therein a fixed transformer 29 and grounded at 30. The secondary 29^a of transformer 29 is connected at one end to the adjustable tap of the secondary 26^a of transformer 26, and the primaries 21^a and 22^a of transformers 21 and 22 are respectively connected in series with the secondaries of the power line transformers. As before, the transformers in the power line measure or evaluate the interfering

effect of that line, and a voltage of proper magnitude and phase angle is introduced into the communication line to neutralize the interfering voltage induced therein by the power line.

Figure 5 shows the neutralizing system of my invention as applied to a parallel including a multigrounded wire for lightning protection. When a multigrounded wire, for example a ground wire for lightning protection, is carried along a power line, a potential is induced and current will flow in that grounded wire. Such current flow will also induce potentials in any nearby communication lines. Since all conductors in a power line are approximately equidistant from the communication line, the induced voltage in the latter line is proportional to the sum of all the currents flowing in the grounded and the ungrounded conductors or wires of the power line. The arrangement of Figure 5 is similar to that of Figure 2, except that a ground wire 31 having multiple grounds 31^a, and provided with a variable transformer 32, is included in the power line P^4. Secondary 32^a of transformer 32 is series connected to secondary 16^c of transformer 16^b and is connected by lead 24^b to primaries 21^a and 22^a of transformers 21 and 22 in wires 19 and 20 of the communication line C. The transformers in the power line evaluate the interfering effect of the power line and apply to the communication line corrective neutralizing voltage of proper phase and magnitude to neutralize the interfering voltage induced in that line by the power line, as before.

The arrangement of Figure 6 is similar to that of Figure 5, except that the wires 14^b, 15^b and 25^a of the power line P^5 are not provided with transformers, and ground wire 31 is provided with a fixed transformer 33 the secondary of which is connected, at one end, by lead 24^b, to one end of primaries 21^a and 22^a of transformers 21 and 22, respectively, the adjustable taps of which are connected by lead 23^b to the other end of secondary 33^a. Since the ground wire 31 is included in the power line, the energy derivable from that wire is adequate for neutralizing the communication line in the manner above described.

Where the power line potentials are high, the use of series transformers in the conductors or wires of that line would be rather expensive. The use of such transformers may be avoided, with a corresponding saving in expense, by the arrangement shown in Figure 7. That arrangement is similar to the arrangement of Figure 6 with certain exceptions. No transformer is included in the ground wire 31^b, which has multiple grounds 31^c, and an auxiliary wire 34, having multiple grounds 34^a, is included in the power line P^6. The current flowing in auxiliary wire 34 is a measure of the interfering effect of the power line and may be used to induce a neutralizing voltage in the communication line. To that end, auxiliary wire 34 has therein a fixed transformer 35 the secondary 35^a of which is connected in series with the respective primaries 21^a and 22^a of the transformers 21 and 22 in wires 19 and 20, respectively, of the communication line C, by leads 23^c and 24^c. The transformer 35 measures or evaluates the interfering effect of the power line and, through its direct coupling to transformers 21 and 22, introduces into the communication line voltage of proper phase and magnitude to neutralize the interfering voltage induced in that line by the power line. The auxiliary wire 34 is much closer to

the power line than to the communication line, and may be considered as being in the power line. Accordingly, the energy derivable from the auxiliary wire 34 is much greater than the voltage induced in the communication line by the power line. That assures that the voltage induced in the communication line wires 19 and 20, by the transformers 21 and 22 thereof, is at least as great as, or even greater than, the interfering voltage induced in such wires by the power line, and practically complete neutralization of the communication line is rendered possible. The method illustrated in Figure 7 may be used with any number or arrangement of power line wires, including power lines with multigrounded neutrals. On a multigrounded system a considerable part—often 40% to 60%—of the phase current may return in the earth. If there are no grounds within the parallel, any one of the system arrangements shown in Figures 1 to 4, inclusive, will operate perfectly. If there are grounds within the parallel, there may be more, or less, residual current in a portion of the parallel other than the portion thereof which is measured or evaluated by the neutralizing system, with the result that there might be a remnant of induction in the communication line, if that were not guarded against. Such remnant of induction can, however, be practically entirely eliminated by proper adjustment of the number of turns of the power line series transformers.

In cases where parallels terminate at either source or loop substations, saving in insulation costs may be effected by installing the power line series transformers in the neutral side of the phase windings. In Figure 8, the parallel terminates at a source 36 of three phase alternating current, the phase windings 36^a, 36^b and 36^c of which are star connected with the neutral point 37 grounded at 37^a, and are respectively connected to the wires or conductors 14^c, 15^d and 25^b of the power line P^7. Transformers 38 are connected in the respective phase windings 36^a, 36^b and 36^c, with their secondaries 38^a series connected and connected in series with primaries 21^a and 22^a, respectively, of transformers 21 and 22 in the communication line wires 19 and 20. The transformers 38 evaluate the interfering effect of the power line P^7 and, through the direct coupling to the transformers in the communication line, apply to the latter line voltage of proper phase and magnitude to neutralize the interfering voltage induced in the communication line by the power line.

The system of Figure 9 is similar to that of Figure 3, except that ground 27 of the latter figure has been omitted and high voltage protective means has been provided between the leads 23 and 24. The high voltage protective means comprises an impedance 40 shunted across leads 23 and 24, which are grounded at 41 and 42, respectively, with intervening spark gaps 43 and 44. This protective means functions in a known manner to protect the transformers against injury due to an abrupt great increase in potential on either the power line or the communication line, due to lightning or other causes, while permitting functioning of the system so as to neutralize interfering voltage induced in the communication line by the power line, in the manner described with reference to Figure 3. The high voltage protective means shown in Figure 9 is illustrative only, and any other suitable known protective means may be used, within the broader aspects of my invention.

In Figure 10 I have shown a neutralizing system embodying my invention, in which the series transformers of the power line are electronically coupled to the neturalizing transformer means of the communication line. The secondaries 45^a, 17^c and 26^a of the transformers 45, 17^b and 26, in the wires 14^d, 15^e and 25^c, respectively, of the power line P^8 are connected in series, as before, it being noted that the transformer 45 is fixed and the transformers 17^b and 26 are variable, though in each instance the transformer may be either fixed or variable, as desired or as conditions may require. The series connected secondaries 45^a, 17^c and 26^a of the power line transformers are connected at one end, by lead 24^e, to ground, at 47, and are connected, at their other end, by lead 46, to the grid circuit of an electron tube 48. The leads 24^e and 46 are shunted by a resistor 46^a, and the grid circuit of tube 48 includes the usual grid leak 49 and "C" battery 50. The filament circuit of tube 48 includes the usual "A" battery 51 and the filament is grounded at one side at 52.

The plate circuit of tube 48 includes a suitable current source, such as the usual "B" battery 53 and, in series in such circuit, primary 54^a of a suitable current transformer 54, which may be an iron core transformer. Secondaries 55 and 56 of transformer 54 are variable and are respectively connected in series with the conductors or wires 19^a and 20^a of the communication line C^1. The interfering effect of the power line P^8 is measured by the series transformers therein. The voltage drop across resistor 46^a, produced by flow of the differential current as measured by the power line transformers, is impressed on the grid of tube 48, causing corresponding but greater changes in the plate current flowing through primary 54^a of transformer 54. That induces corresponding voltage in the secondaries 55 and 56, thereby applying to communication line wires 19^a and 20^a voltage of proper phase and magnitude to neutralize the interfering voltage induced in those wires by the power line. Electronic coupling between the series transformers of the power line and the neutralizing transformer means of the communication line, such as shown in Figure 10, has certain advantages over electromagnetic coupling. In electronic coupling the degree of neutralization is readily variable to follow the slight seasonal changes in earth resistivity, or to allow for changes in the length of a parallel due to switching. If desired, in the system of Figure 10, resistance coupling may be used instead of electronic coupling.

The system of Figure 11 is similar to that of Figure 5, except that the secondaries of the power line series current transformers are connected in shunt across the leads 24^f and 23^d, instead of being connected in series as in Figure 5. Under conditions of unbalance of the power line such as are ordinarily encountered, connecting the secondaries of the power line transformers in series gives entirely satisfactory results with respect to neutralizing the interfering voltages induced in the communication line by the power line, and probably would be satisfactory even in cases of exceptionally great unbalance of the power line. However, by connecting the secondaries of the power line transformers in shunt, I render available more energy for neutralizing the communication line, in the case of exceptionally great unbalance of the power line, than would be available were such secondaries connected in series, thereby assuring complete neutralizing of

the communication line even under such exceptional conditions. In either case—whether the power line secondaries be connected in series or in shunt—the power line transformers evaluate the interfering effect, or current differential, of the power line with respect to the communication line and provide adequate energy for neutralizing the communication line, in the manner above explained. From what has been said, it will be understood that, if desired, in the systems of Figures 1 to 5, inclusive, the secondaries of the power line transformers may be connected in shunt instead of in series and, in either case, will function as and for the purpose previously described. Likewise, in the systems of Figures 8 to 10, inclusive, the secondaries of the power line transformers may be connected in shunt.

In general only one neutralizing system will be required for each parallel. Where the parallel is of considerable length, or the power line or the communication line is sectionalized or has taps taken off, or where it appears advisable for other reasons, a plurality of neutralizing systems may be included in a parallel. In such case, each system is adjusted to neutralize that portion of the total interfering induction which is likely to arise from the corresponding area of the parallel.

In order to facilitate illustration and description of the neturalizing system of my invention, I have shown it as used with a communication line spaced an appreciable distance from the power line. That is not essential, however, and it may be used on communication lines carried on either the same poles or cable runs as the power line, or on different poles or cable runs. The neutralizing system of my invention is completely automatic, requires no attendance and but little maintenance, and is automatically taken out of service with the power line, unless that line is grounded, in which case it remains effective for neutralizing interfering voltage induced in the communication line by the power line arising from currents which may circulate in the grounded power line conductors or wires.

While it is, in general, simpler to evaluate the interfering effect of the power line by series current transformers, with but two leads connecting them to the communication line transformers, as shown, the system of my invention comprehends connecting each of the series transformers in the power line wires, by separate leads, to the transformers in the communication line, and there evaluating the interfering effect of the power line and applying to the communication line wires voltage of proper phase and magnitude to neutralize the interfering voltage induced by the power line.

I have shown, for simplicity of illustration, a single communication line comprising but two conductors or wires. It will be understood, however, that the neutralizing system of my invention is equally applicable to neutralizing the induced voltages on communication circuits or leads—a plurality of circuits—comprising any number of conductors or wires. In such cases, each installation of series transformers in the power line may be connected by leads to the corresponding transformers in the different classes or routes of communication circuits regardless of their position or separation with respect to the power line, the transformers in the power line, or in the communication line, or in both, being, of course, properly adjusted to effect the desired neutralizing of the interfering voltage induced in the communication line by the power line. Also, if a

route include two or more power lines paralleling a communication line or lead, the series transformers in each of the power lines may be connected to the transformers of the communication line or lead for neutralizing the interfering voltage induced therein by the power lines, in the manner above described. It is possible, by the system of my invention, to evaluate the interfering effect of all power lines along a route regardless of the number of such lines, the number of phases in each line, and the voltages of the various power lines, and to apply neutralizing voltage to a communication line or lead included in a parallel of such route, as will be understood from the preceding description of such system.

As has been indicated, and as will be understood by those skilled in the art, changes in detail may be made in my invention, both as to the system and as to the method, without departing from the field and scope thereof, and I intend to include all such variations, as fall within the scope of the appended claims, in this application in which the preferred forms only of my invention have been disclosed.

I claim:

1. In a neutralizing system comprising a power line and a communication line having portions thereof in adjacent parallel relation, each of said lines comprising a plurality of wires, current transformers having their primaries respectively in series with the power line wires and their secondaries connected in series, neutralizing transformers having their secondaries respectively in series with the communication line wires and their primaries connected in shunt, and means metallically connecting the primaries of said neutralizing transformers respectively in series with the secondaries of said power line transformers.

2. In a neutralizing system comprising a power line and a communication line having portions thereof in adjacent parallel relation, the power line comprising a plurality of transmission wires and a ground wire in the parallel thereof and the communication line comprising a plurality of transmission wires, current transformers having their primaries respectively in series with the power line transmission and ground wires and their secondaries connected in series, neutralizing transformers having their secondaries respectively in series with the communication line wires and their primaries connected in shunt, and means metallically connecting the primaries of said neutralizing transformers respectively in series with the secondaries of said power line transformers.

3. In a neutralizing system comprising a power line and a communication line having portions thereof in adjacent parallel relation, the power line comprising a plurality of transmission wires and a ground wire in the parallel thereof and the communication line comprising a plurality of transmission wires, a current transformer having its primary in series with said ground wire, neutralizing transformers having their secondaries respectively in series with the communication line wires and their primaries connected in shunt, and means metallically connecting the primaries of said neutralizing transformers respectively in series with the secondary of said ground wire transformer.

4. In a neutralizing system comprising a power line and a commmunication line having portions thereof in adjacent parallel relation, each of said lines comprising a plurality of wires, current

transformers having their secondaries series connected and their primaries respectively connected in series with the power line wires, neutralizing transformer means having secondaries respectively connected in series with the communication line wires, and means electronically coupling the secondaries of the power line transformers to the primary of said neutralizing transformer means.

5. In a neutralizing system comprising a power line and a communication line having portions thereof in adjacent parallel relation, each of said lines comprising a plurality of wires, current transformers having their secondaries series connected and their primaries respectively connected in series with the power line wires, an electron tube having grid, filament and plate circuits, a neutralizing transformer having a primary in series in the plate circuit of said tube and secondaries respectively connected in series with the communication line wires, leads respectively connecting one end of the secondaries of the power line transformers to ground and the other end thereof to the grid of said tube, and a resistor shunted across said leads.

6. In a neutralizing system comprising a power line and a communication line having portions thereof in adjacent parallel relation, each of said lines comprising a plurality of wires, current transformers having their primaries respectively connected in series with the power line wires and their secondaries connected in shunt, and neutralizing transformers having their secondaries respectively in series with the communication line wires and their primaries connected in shunt with each other and respectively in shunt with the secondaries of said power line transformers.

7. In a neutralizing system comprising a power line and a communication line having portions thereof in adjacent parallel relation, the power line comprising a plurality of transmission wires and a ground wire in the parallel thereof and the communication line comprising a plurality of transmission wires, current transformers having their primaries respectively in series with the power line transmission and ground wires and their secondaries connected in shunt, and neutralizing transformers having their secondaries respectively in series with the communication line wires and their primaries connected in shunt with each other and respectively in shunt with the secondaries of said power line transformers.

8. Means for neutralizing the voltage induced by a power line in a parallel communication line formed by a pair of conductors comprising, in combination, secondary winding means inductively related to said power line for induction therein of a voltage which is a function of said induced voltage, a primary winding individual to and inductively related to each of said conductors of said communication line, and means coupling said secondary winding means to each of said primary windings whereby a voltage is induced in said communication line to neutralize said induced voltage.

9. Means for neutralizing the voltage induced by a power line in a parallel communication line formed by a pair of conductors comprising, in combination, secondary winding means inductively related to said power line for induction therein of a voltage which is a function of said induced voltage, a primary winding individual to and inductively related to each of said conductors of said communication line, and conductor means interconnecting said secondary winding means to each of said primary windings whereby a voltage is induced in said communication line to neutralize said induced voltage.

10. Means for neutralizing the voltage induced by a power line in a parallel communication line formed by a pair of conductors comprising, in combination, secondary winding means inductively related to said power line for induction therein of a voltage which is a function of said induced voltage, a primary winding individual to and inductively related to each of said conductors of said communication line, means coupling said secondary winding means to each of said primary windings whereby a voltage is induced in said communication line to neutralize said induced voltage, and means for adjusting the effective number of turns of each of said primary windings.

HOLLA EDWIN WEAVER.

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