L. ESPENSCHIED.

MEANS FOR NEUTRALIZING INTERFERING DISTURBANCES.

APPLICATION FILED DEC. 5, 1918.

1,362,613. **Patented Dec. 21, 1920.**

4 SHEETS—SHEET 1.

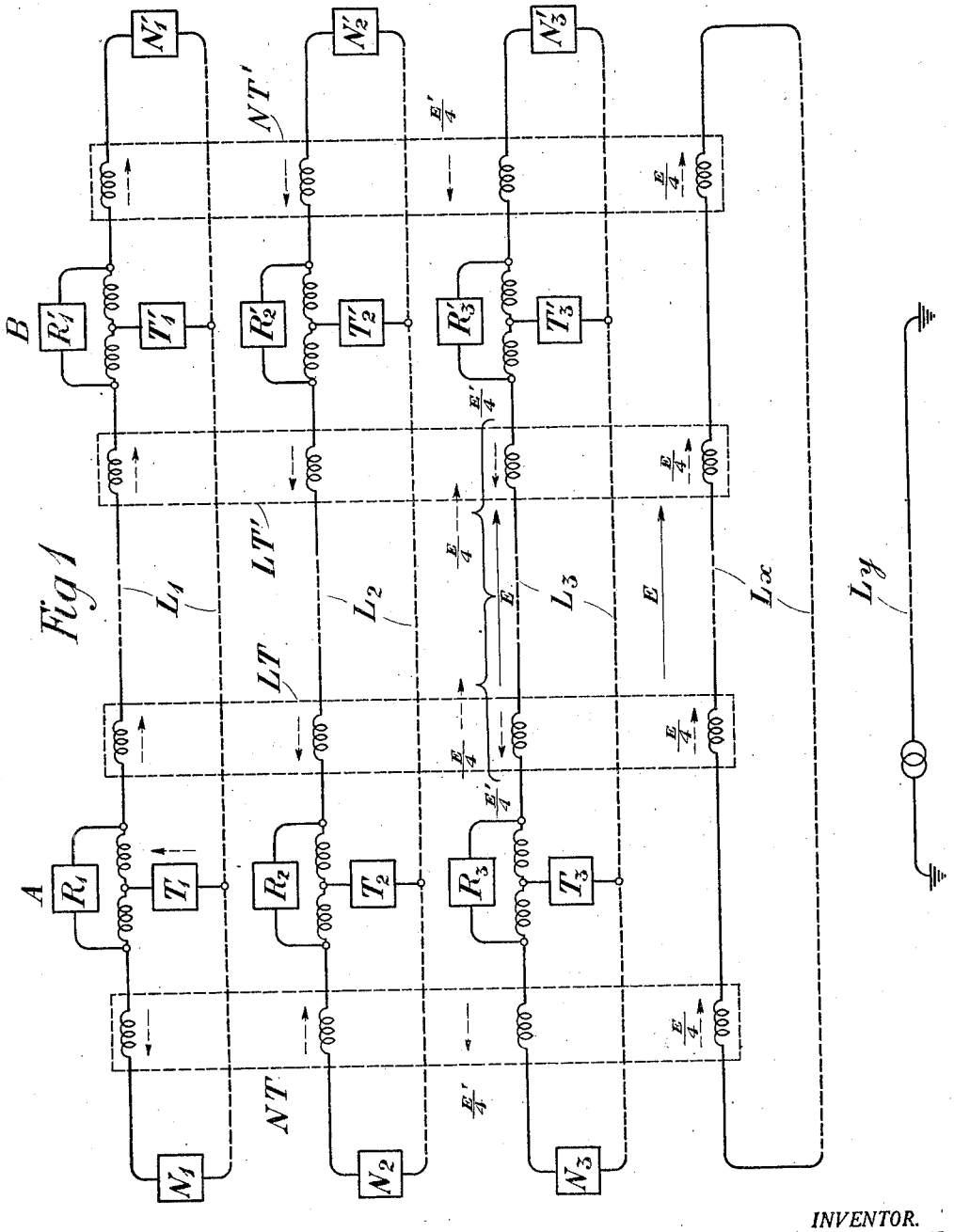


Fig 1

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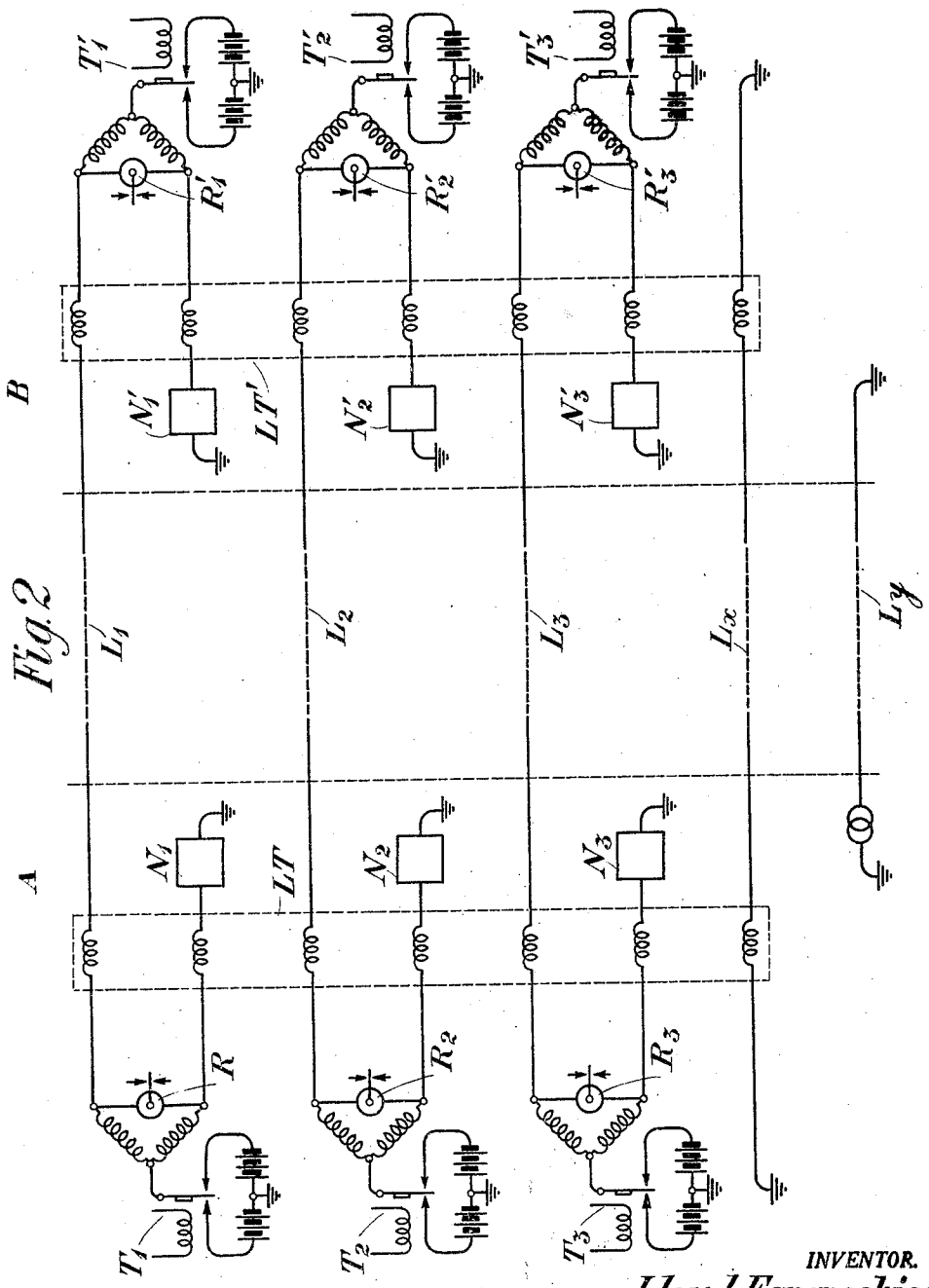


Fig. 2

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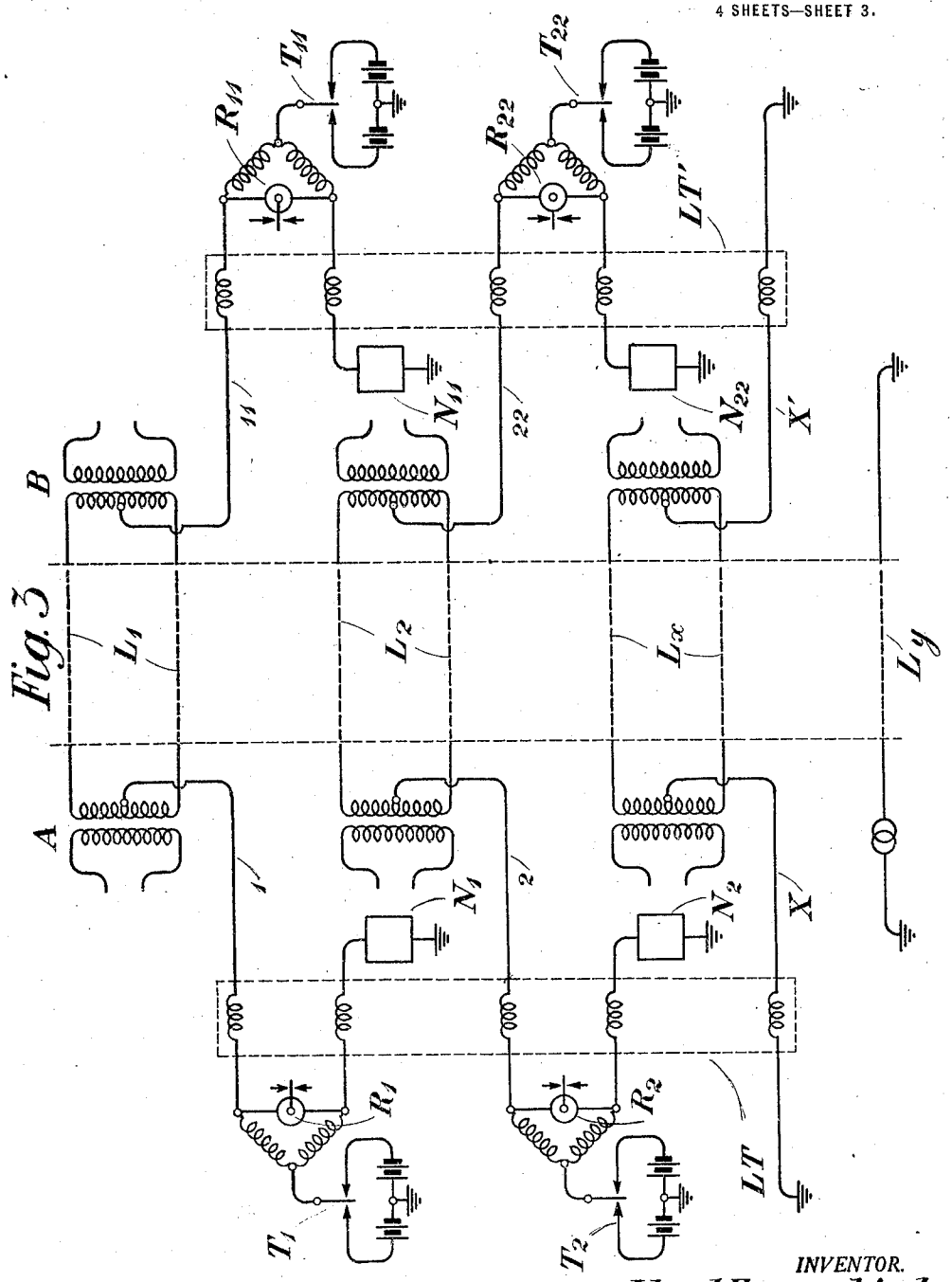


Fig. 3

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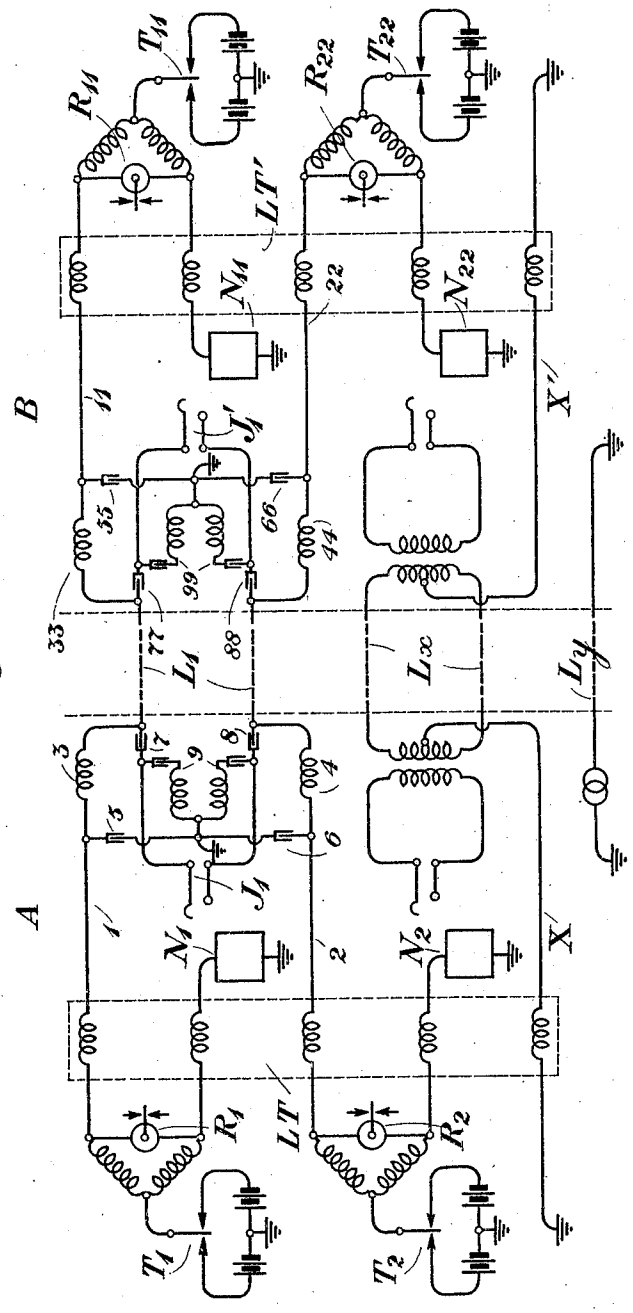
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4 SHEETS—SHEET 4.

Fig. 4



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MEANS FOR NEUTRALIZING INTERFERING DISTURBANCES.

1,362,613. Specification of Letters Patent. **Patented Dec. 21, 1920.**

Application filed December 5, 1918. Serial No. 265,456.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, Long Island, in the county of Queens and State of New York, have invented certain Improvements in Means for Neutralizing Interfering Disturbances, of which the following is a specification.

This invention relates to transmission circuits and more particularly to means for preventing interference where a plurality of transmission circuits parallel each other between two stations.

The invention has for one of its objects the provision of a neutralizing system which not only protects the transmission circuits from the effects of foreign electrical systems but also avoids introducing any mutual interference between the said circuits, although other and further objects of the invention will more fully hereinafter appear.

Where a number of transmission circuits parallel each other interfering electromotive forces may be set up in the circuits either due to mutual induction between the circuits or to the disturbing action of some neighboring electric system such as a power circuit. The most common sources of interference are traction or power systems operating on frequencies of the order of fifteen to sixty cycles although low frequency telegraph circuits may also cause disturbing effects. These low frequency electromotive forces tend to interfere mostly with the corresponding low frequency circuits of the transmission systems such as ordinary telegraph circuits. The present invention therefore applies especially to the protection of low frequency circuits such as telegraph circuits although it is of course not limited to this particular application.

It has been heretofore proposed to overcome interferences of this character by means of neutralizing transformer system operating to impose upon the affected circuits an electromotive force equal to and opposed to the original interfering electromotive force. Ordinarily for the purposes of economy a neutralizing system including a single transformer equipped with a plurality of line windings is used for protecting simultaneously a plurality of transmission circuits, one line winding of the transformer being connected in each line wire of each transmission circuit and another line winding being connected in an auxiliary circuit which is subject to the same influence as regards the disturbing source as the transmission circuits to be protected, these line windings being assembled on a common transformer core and having between them mutual inductance. In the usual case where the neutralizing system is designed for neutralizing low frequency induction the mutual inductance between the several line windings may be so large as to cause mutual interference between the low frequency signaling channels.

It has been proposed in accordance with the patent to Shaw 1222810 of April 17, 1917 to overcome this difficulty by locating the neutralizing transformer at or near the terminus of the circuits. The terminal location of the transformer is frequently desirable not only because of the simplification of the problem of housing and maintenance, but furthermore because in the case of the telegraph circuits composited on telephone circuits where it is sometimes unnecessary to protect the telephone channel, the transformer windings may be restricted to the Morse legs thereby avoiding the telephone loss which would be occasioned by their presence in the telephone circuit. This arrangement of the transformer windings however introduces serious interference between the outgoing currents of one channel and the weaker incoming currents of another channel. The interference due to incoming currents in one channel imposing disturbing electromotive force upon incoming currents of another channel, however is of small importance because the received currents are of such small magnitude as to produce unappreciable effects. The present invention has particular reference to preventing the introduction of interference of the first mentioned type viz.: that between channels in which currents are being transmitted in opposite directions.

The objects of this invention are secured and the difficulties above referred to are overcome by providing duplicate transformer arrangements in both the line and the artificial line of the protected circuit. One line winding is included in each line wire and a corresponding winding is included in each artificial line circuit while the primary windings of the transformer arrangement are included in the auxiliary or neutralizing circuit. In this way the mutual induction normally set up by the transformer between the real lines of the trans-

mission circuits is balanced with respect to the effect of outgoing upon incoming transmission by an equivalent mutual induction between the artificial lines.

The invention will be more fully understood by reference to the following description when read in connection with the accompanying drawings in which Figure 1 constitutes a circuit diagram showing the general layout of the system in accordance with this invention; Fig. 2 is a diagram illustrating the invention as applied to a plurality of telegraph circuits; Fig. 3 is a diagram illustrating the invention as applied to telegraph circuits simplexed upon telephone lines; and Fig. 4 is a diagrammatic representation of a system embodying this invention as applied to telegraph circuits superposed upon telephone circuits in accordance with the well known composite system of telephony and telegraphy.

Referring to Fig. 1 three transmission lines L_1, L_2 and L_3 are shown extending between two stations A and B the return conductors of the lines being shown in dotted lines to indicate that either a metallic or ground return may be used. Each line is provided with a transmitting and receiving apparatus and a balancing artificial line at each station. For instance the line L_1 is provided with transmitting arrangements T_1 and T_1' bridged across the junction points between the line and the balancing artificial lines N_1 and N_1'. The receiving apparatus R_1 and R_1' at the station is connected across equal potential points in the line and artificial line with regard to the transmitting apparatus, equal inductance being included between the terminals of the receiving apparatus and one terminal of the transmitting apparatus. The arrangement as regards the line L_2 and L_3 is the same as that described with reference to line L_1 and need not be further discussed.

A foreign disturbing system paralleling the above described transmission circuits is indicated at L_y. In order to counteract the disturbing effects of the system L_y a neutralizing circuit L_x is provided, said circuit paralleling the several transmission circuits so that disturbances are produced therein similar to those produced in the transmission circuits. A neutralizing transformer L T including a plurality of windings is provided, one winding being included in each of the lines L_1, L_2 and L_3 at station A while a primary winding is included in the neutralizing circuit L_x. An equivalent transformer N T is also provided at station A having an primary winding in the neutralizing circuit L_x and line windings in circuit of each of the artificial lines N_1, N_2 and N_3. Similarly at station B a neutralizing transformer L T′ is provided for the lines and an equivalent transformer N T′ is provided for the artificial lines.

The action of the balanced transformer arrangement above described in preventing the introduction of cross-interferences between the transmission circuits is as follows: Assuming that the transmitting apparatus T_1 is sending, the arrows under the transformer windings in line L_1 and artificial line N_1 at station A indicate the instantaneous values and directions of flow of currents sent into the line and artificial line from the transmitter. The varying line current induces through the line transformer a potential and current in the line L_2 as indicated by the arrow above the line winding in the line L_2 at station A. Similarly the varying artificial line current flowing through the artificial line N_1 induces through the balancing transformer a potential and current in the artificial line N_2 as indicated by the arrows above the transformer winding of said circuit. These two induced currents are equal (by the symmetry of the systems and the identity of the transformers) and mutually opposed with respect to the receiving apparatus R_2 of the line L_2 and consequently the receiving apparatus of said line is unaffected by the transmitting apparatus of the line L_1 at the same station.

Similar balanced relations obtain between all other combinations of circuits within the group. This balance between sending and receiving channels of different circuits at at the same station is obtained at the expense of an increased unbalanced mutual inductance between similarly directed channels. This is permissible however since interferference between receiving channels is usually negligibly small. The action in this respect may be understood by reference to station B. The arrows beneath the transformer windings of the line L_1 and the artificial line N_1' at said station indicate the value and direction of the current flowing due to the action of the transmitter T_1 at station A. These currents induce potentials and currents in the line L_2 and artificial line N_2' as indicated by the arrows above the windings of the transformers in said circuits. It will be seen that the interfering currents in the line and artificial line do not oppose each other so that the interference between currents received at the same station is increased. Owing to the small magnitude of the received currents however this result while undesirable is of little consequence.

That the balancing arrangement of the neutralizing system does not sacrifice the necessary action of neutralizing foreign disturbing electromotive forces from the circuit L_y may be shown as follows with reference to the drawing of Fig. 1. Assume the interfering electromotive forces impressed upon all circuits of the group to be E. This electromotive force divides equally between the primary windings of

the four equal transformers in the circuit L_x. For simplicity in explanation the line voltage drop will be neglected. Then a voltage $\frac{E}{4}$ is impressed across each of the four windings as indicated. This is transformed to an equal counter-electromotive force $\frac{E'}{4}$ across each of the secondary windings of each transformer as indicated above the transmission circuit L_3. Now of these electromotive forces the two in the line proper oppose the original interfering electromotive force E and reduce it to one-half of its original value.

$$\left(E-\frac{E'}{4}-\frac{E'}{4}=\frac{E}{2}\right).$$

The remaining one-half

$$\left(\frac{E}{4}+\frac{E}{4}\right.$$

on the drawing) is then neutralized with respect to its effect upon the receiving apparatus of the transmission circuits by the counter-electromotive forces set up by the balancing transformer

$$\left(\frac{E'}{4}+\frac{E'}{4}\right.$$

on the drawing). The condition of neutralization is therefore one in which the line transformers neutralize one-half and the artificial line balancing transformers the other one-half of the disturbing electromotive force.

The line and balancing transformer may be combined upon a common core and made to be physically a single unit. This consolidation is indicated in Fig. 2, in which transformers L T and L T′ are provided with windings in both the line and the artificial line side of each transmission circuit. Here the transmission circuits L_1, L_2 and L_3 are illustrated as ordinary ground return duplex telegraph circuits. The line and balancing windings for both the telegraph circuits (the secondaries of the neutralizing system) and the primary neutralizing circuit are merged into one transformer. The two windings of each circuit are connected mutual series aiding around the interference current path so that they combine in neutralizing the interfering electromotive force from the disturbing circuit L_y. They are mutually opposed to transmitted telegraph currents and thereby prevent the latter from interfering with the received currents of other circuits. This arrangement is not only more economical from a cost standpoint but is better from a telegraph standpoint because it facilitates obtaining and maintaining the duplex balance, by causing changes in the effective impedance of the transformers resulting from saturation effects, to affect alike the line and balancing line sides of the circuits. Furthermore the windings present less inductance to the outgoing telegraph currents by virtue of their close and mutually opposed coupling. The arrangement is also better from the standpoint of the neutralization action of the transformers since saturation effects in the transformers due to Morse currents and the resulting reduction of neutralization efficiency are avoided.

Fig. 3 illustrates a similar arrangement as applied to telegraph circuits superposed on telephone circuits by a simplex arrangement. In the drawing L_1 and L_2 represent telephone lines extending between two stations A and B where they are connected to their terminal arrangements through transformers of the well known phantom type. Morse legs 1 and 2 are connected to midpoints of the windings of the transformers in lines L_1 and L_2 at station A. Similarly Morse legs 11 and 22 are connected to the midpoints of the transformers at station B. The Morse legs terminate in the usual duplex telegraph sets including artificial lines N_1, N_2, N_{11} and N_{22}. A third telephone circuit L_x similar in all respects to the telephone circuits L and L_2 is provided with ground taps X and X′ connected to the midpoints of the windings of the terminal transformers. This circuit functions as the neutralizing circuit of the system as it is related to the disturbing system L_y in a manner similar to that of the lines L_1 and L_2. Neutralization transformers L T and L T′ are provided, the former having secondary windings in each of the Morse legs and each of the artificial line circuits at station A and a primary winding in the ground tap X. In a similar manner the transformer L T′ has secondary windings in the Morse legs and artificial line circuits at station B while its primary winding is in the ground tap X′. The operation of this circuit so far as prevention of interference is concerned is in all respects similar to that of Fig. 2 and need not be further described.

Fig. 4 illustrates the invention as applied to telegraph circuits superimposed upon telephone circuits by compositing the circuits. In this figure telephone line L_1 terminates at stations A and B in jacks J_1 and J_1'. Telegraph legs 1 and 2 are led from each of the line wires of the telephone circuit at station A, similar legs 11 and 22 being led from the line wires of the telephone circuit at station B. Each of the telephone legs terminates in the usual duplex telegraph sets including transmitters, receivers and artificial lines as indicated. Included in the legs 1 and 2 are inductances 3 and 4 to prevent a flow of high frequency talking current to the Morse legs, similar inductances 33 and 44 being included in the Morse

legs 11 and 22. Capacities 5, 6, 55 and 66 are shunted to ground beyond the inductances to form by-passes for any telephone currents which may be transmitted through the inductances. Condensers 7 and 8, 77 and 88 are inserted in the telephone conductors beyond the Morse legs said condensers being so proportioned as to permit the passage of the relatively high frequency telephone currents and prevent the passage of low frequency Morse currents. In order to shunt to ground any Morse currents which may pass through the condensers ground taps 9 and 99 including capacity and inductances are provided. Another telephone circuit L_x may be used as the neutralizing circuit and for this purpose connections X and X′ similar to those described in Fig. 3 are provided. Neutralizing transformers L T and L T′ are arranged with secondary windings in the various Morse legs and artificial line circuits and primary windings in the ground taps X and X′. The operation of this circuit with regard to neutralization of disturbing electromotive forces therein either from systems of the same character or from foreign electrical systems is the same as that already described in connection with Fig. 2 and need not be further discussed.

By means of the arrangements above described a simple and yet efficient means is provided for neutralizing interfering electromotive forces and while the invention has been shown embodied in certain specific organizations it will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a transmission system, a transmission circuit, a source of signaling current therefor, a balancing circuit therefor, a source of disturbing electromotive force independent of said signaling source, a third source for counteracting said disturbing source, said third source being inductively related to both said transmission circuit and said balancing circuit.

2. In a transmission system, a plurality of transmission circuits having lumped mutual impedances, balancing circuits for each transmission circuit, said balancing circuits having lumped mutual impedances simulating those of the transmission circuits.

3. In a transmission system, a transmission circuit, a source of signaling current therefor, transmitting and receiving apparatus therefor, a balancing circuit for said signaling circuit to render said receiving apparatus unresponsive to said transmitting apparatus, a source of disturbing electromotive force independent of said signaling source, a third source for counteracting said disturbing source, said third source being inductively related to both said transmission circuit and said balancing circuit.

4. In a transmission system, a plurality of transmission circuits, balancing circuits for each transmission circuit, a disturbing source of electromotive force, an auxiliary circuit for counteracting said disturbing source, lumped mutual impedances in said transmission circuits and auxiliary circuit, and lumped mutual impedances in said auxiliary circuit and balancing circuits for simulating said first mentioned impedances.

5. In a transmission system, a plurality of transmission circuits, sources of signaling current therefor, balancing circuits for each transmission circuit, an auxiliary circuit, a source independent of said signaling sources for producing disturbing electromotive forces in said transmission circuits and counteracting electromotive forces in said auxiliary circuit, said auxiliary circuit being inductively related to said transmission circuits and balancing circuits.

6. In a transmission system, a plurality of transmission circuits interconnecting two stations, transmitting and receiving apparatus for each circuit at each station, a balancing circuit at each station for each transmission circuit to render the receiving apparatus of any line at each station unresponsive to the transmitting apparatus of said line thereat, lumped mutual impedances for said transmission circuits, and lumped mutual impedances for said balancing circuits simulating those of the transmission circuits, whereby the transmitting apparatus of any transmission circuit at a given station is without effect upon the receiving apparatus of other transmission circuits at that station.

7. In a transmission system, a plurality of transmission circuits interconnecting two stations, transmitting and receiving apparatus for each circuit at each station, a balancing circuit at each station for each transmission circuit to render the receiving apparatus of any line at each station unresponsive to the transmitting apparatus of said line thereat, an auxiliary circuit, a disturbing source independent of said transmitting and receiving apparatus for producing disturbing electromotive forces in said transmission circuits and counteracting disturbances in said auxiliary circuit, and mutual inductive connections between said auxiliary circuit and said transmission and balancing circuits, whereby the disturbing effects in said transmission circuits are counteracted and the transmitting apparatus of any transmission circuit at a given station is without effect upon the receiving apparatus of other transmission circuits at that station.

8. In a transmission system, a telephone circuit, a telegraph circuit superposed thereon, a source of signaling current therefor, a

balancing circuit for said telegraph circuit, a source of disturbing electromotive force independent of said signaling source, a third source for counteracting said disturbing source, said third source being inductively related to said telegraph circuit and balancing circuit external to the telephone circuit.

9. In a transmission system, a plurality of telephone circuits, telegraph circuits superposed thereon, balancing circuits for said telegraph circuits, lumped mutual impedances for said telegraph circuits external to said telephone circuits, and lumped mutual impedances for said balancing circuits simulating those of the telegraph circuits.

10. In a transmission system, a plurality of telephone circuits extending between two stations, telegraph circuits superposed thereon, transmitting and receiving apparatus for each telegraph circuit at each station, a balancing circuit for each telegraph circuit whereby the receiving apparatus of any telegraph circuit at a given station is rendered unresponsive to the transmitting apparatus of said circuit thereat, an auxiliary circuit, a disturbing source independent of said transmitting and receiving apparatus for producing disturbing electromotive forces in said telegraph circuits and counteracting electromotive forces in said auxiliary circuit, mutual inductive connections between said auxiliary circuit and said telegraph circuits external to said telephone circuits and similar mutual inductive connections between said auxiliary circuit and said balancing circuits, whereby the disturbing effects in said telegraph circuits are counteracted and the transmitting apparatus of any telegraph circuit at a given station is without effect upon the receiving apparatus of other telegraph circuits at that station.

In testimony whereof I have signed my name to this specification this twenty-seventh day of November, 1918.

LLOYD ESPENSCHIED.