Aug. 19, 1941.

E. B. MECHLING

2,253,189

TRANSMISSION DEVICE

Filed Jan. 18, 1940

FIG. 1

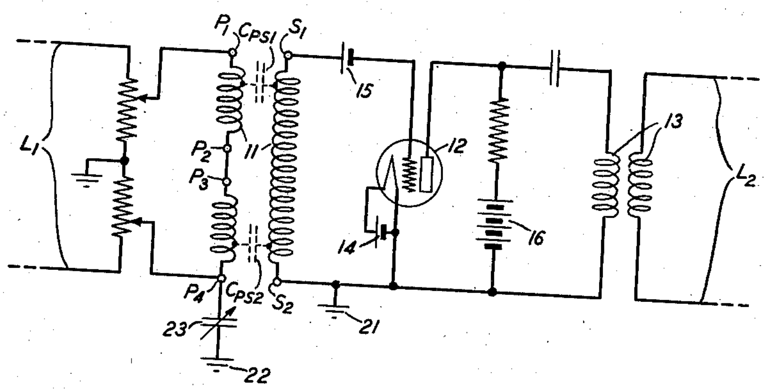
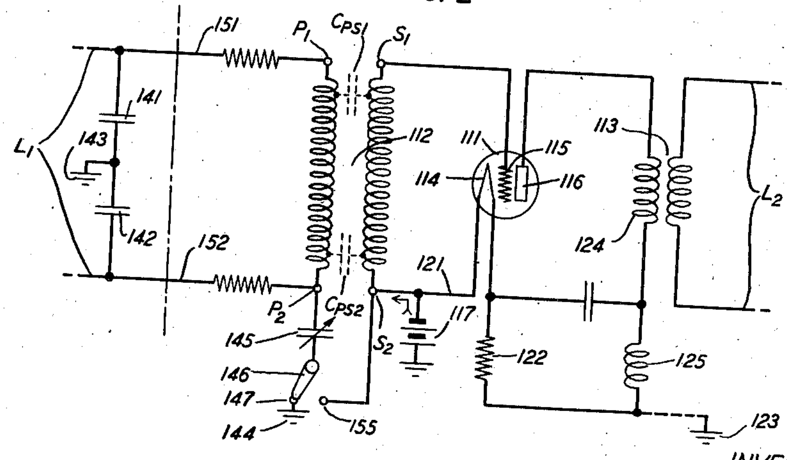


FIG. 2



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TRANSMISSION DEVICE

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9 Claims. (Cl. 178—44)

This invention relates to transmission devices and more particularly to an input transformer for use in vacuum tube amplifier or repeater circuits.

An object of the invention is the improvement of transmission over a line which includes an amplifier or a repeater.

A more specific object of the invention is the reduction of distortion and other deleterious effects arising from the flow of currents in the longitudinal circuit of a transmission line.

In the use of either open wire or cable circuits for communication purposes considerable difficulty is very often experienced due to the proximity of power lines and other communication circuits. Induction from such neighboring circuits often gives rise to longitudinal voltages in the communication circuit which may result in objectionable distortion and noise. Current flow in the longitudinal circuit of the communication circuit may be caused also by elements of the communication circuit itself such, for example, as the source of voltage provided for the vacuum tube amplifiers.

A feature of the present invention comprises means readily applied to existing components of the communication circuit whereby the effects of longitudinal voltages therein are nullified and noise and distortion are prevented.

In accordance with a specific embodiment of the invention a path to ground through a suitable network, which may be a variable condenser, is connected to an external terminal of the primary winding of the input transformer associated with a vacuum tube amplifier or repeater. Provision of this path to ground results in setting up in the primary winding a current which is effective to establish a voltage rise in the secondary which offsets the voltage drop therein resulting from the action of longitudinal currents passing through the interwinding capacitance of the transformer to ground.

A complete understanding of the invention as well as appreciation of the valuable features thereof may be gained from consideration of the subsequent detailed description in connection with the drawing in which:

Fig. 1 shows a vacuum tube repeater circuit the input transformer of which is provided with corrective means in accordance with features of the present invention; and

Fig. 2 shows a vacuum tube amplifier circuit the input transformer of which likewise is provided with corrective means in accordance with features of the present invention.

Referring now to Fig. 1, a portion of a conventional vacuum tube repeater circuit is illustrated comprising an input transformer **11**, vacuum tube amplifier **12**, output transformer **13** and the usual potential sources viz. filament battery **14**, grid biasing battery **15** and plate battery **16**. Terminal S_2 of the secondary winding of input transformer **11** is connected to ground **21**. The windings of input transformer **11** are in series aiding relationship when connected P_1 to P_2 to P_3 to P_4 to S_2 to S_1. Signaling currents received over incoming line L_1 are applied to amplifier **12** through input transformer **11** and are applied in amplified form through output transformer **13** to outgoing line L_2 in the usual manner.

Terminal P_4 of the primary winding of input transformer **11** is connected to ground **22** over a path which includes variable condenser **23**, this path to ground through the variable condenser constituting the corrective means of the embodiment of the present invention disclosed in Fig. 1. Condenser **23** should be of relatively small capacity in order that the high frequency signaling currents will not be affected appreciably by this path to ground.

In order to describe the operation of the corrective means, i. e., the path to ground **22** through capacity **23**, let us assume first that this corrective means be absent and that a longitudinal voltage has been set up in line L_1 through inductive action. This longitudinal voltage will set up a longitudinal current between the primary and secondary windings of input transformer **11** to ground **21** through the interwinding capacitances of the transformer represented by the dotted capacities C_{PS1} and C_{PS2}. This current results in an impedance drop in the secondary winding of transformer **11** which impedance drop, if we arbitrarily choose the moment when the direction of current is from coil to ground, will be from terminal S_1 to S_2. This impedance drop is highly undesirable as it results in distortion of the wave being transmitted.

Now let us see how the provision of the corrective means of the present invention, i. e., the path to ground **22** through capacity **23**, acts to neutralize the above undesirable effect. With the connection of this path to ground to terminal P_4 of the primary winding, the longitudinal voltage also sets up, in addition to the current in the secondary winding referred to above, a current in the primary winding through condenser **23** to ground **22**. This current will result in an impedance drop in the primary winding which, assuming the same current direction as before, will be from terminal P_1 to P_4. This impedance drop by transformer action, will result in a voltage rise in the secondary winding from terminal S_1 to S_2. Thus a voltage rise is established in the secondary winding which opposes the drop resulting from the longitudinal current passing through the interwinding capacities to ground **21**. By proper adjustment of condenser **23** neutralization may be attained.

In view of the fact that provision of the corrective means described above involves merely connection of a simple network to one of the external terminals of the input transformer it will be apparent that such corrective means can be readily and economically added to apparatus already being used in the field. This is considered an especially valuable feature of the invention as it has been applicant's experience that longitudinal voltage troubles are often not foreseen when a particular communication line is set up and, indeed, often arise only when power lines and the like are subsequently established in proximity to the communication circuit.

Referring now to Fig. 2, a vacuum tube amplifier circuit is disclosed including vacuum tube amplifier **111**, input transformer **112** and output transformer **113**. Amplifier tube **111** is provided with cathode **114**, grid **115** and anode **116**. Cathode **114** is energized by battery **117** over a path traced from battery **117**, conductor **121**, cathode **114**, resistance **122** to ground **123**; when the amplifier is in operation battery **117** also supplies potential to anode **116** over a path traced from battery **117**, conductor **121**, cathode **114**, through the space charge path of the vacuum tube to anode **116**, primary winding **124** of output transformer **113**, choke coil **125** to ground **123**. The windings of input transformer **112** are in series aiding relationship when connected P_1 to P_2 to S_1 to S_2. Signaling currents received over incoming line L_1 are applied to amplifier tube **111** through input transformer **112** and are applied in amplified form through output transformer **113** to outgoing line L_2 in the usual manner.

Wire-to-ground capacitance of the incoming line is represented by condensers **141** and **142** and ground **143**.

Terminal P_2 of input transformer **112** is connected to ground **144** over a path which includes variable condenser **145**, switch **146** and contact **147**, this path to ground through the variable condenser constituting the corrective means of the embodiment of the invention illustrated in Fig. 2. Condenser **145** should be of relatively small capacity in order that the high frequency signaling currents will not be affected appreciably by this path to ground.

In order to describe the operation of the corrective means disclosed in Fig. 2 let us assume first, as we did in the description of Fig. 1, above, that the corrective means be absent. A current which we will refer to as the "noise current" will be set up, by any noise voltage which may exist across battery **117**, between the primary and secondary windings of input transformer **112** due to the interwinding capacitances represented by the dotted capacities C_{PS1} and C_{PS2} and will flow over conductors **151** and **152** respectively, of incoming line L_1 to ground **143**. This noise current results in an impedance drop in the secondary winding of input transformer **112** which impedance drop, if we arbitrarily choose the moment when the "noise voltage" is in the direction indicated by the arrow, will be from terminal S_2 to S_1. This impedance drop is highly undesirable as it results in noise and distortion in outgoing line L_2.

Now let us see how the provision of the corrective means of the present invention, i. e., the path to ground **144** through capacity **145**, tends to overcome the above undesirable effect. With the connection of this path to ground to terminal P_2 of the primary winding a component of the noise current will pass through the primary winding to ground **144**. This current produces an impedance drop in the primary winding which, assuming the same direction of noise voltage as before, will be from terminal P_1 to P_2. By transformer action this impedance drop from terminal P_1 to P_2 of the primary will appear across the secondary winding as an impedance drop from terminal S_1 to S_2. By proper adjustment of condenser **145** this drop from terminal S_1 to S_2 may be caused to exactly neutralize the drop from terminal S_2 to S_1 caused by the flow of noise current in the secondary as explained above.

It is possible that under certain conditions the vacuum tube circuit may be subjected both to longitudinal voltages of the nature discussed above in reference to Fig. 1 and noise current of the nature discussed in reference to Fig. 2. In such event switch **146** (Fig. 2) may be operated to contact **155** whereupon condenser **145** will obtain ground through battery **117**. The windings of input transformer **112** should be rearranged to be in series aiding relationship when connected P_1 to P_2 to S_2 to S_1.

The effects of longitudinal noise voltages are neutralized by this modification of the arrangement described above with reference to Fig. 2 in the manner that has been described in detail in reference to Fig. 1 while the effects of battery noise voltage are neutralized in a manner generally similar to that discussed above in reference to Fig. 2. In the latter case, a battery noise current will be set up, as explained above, between the primary and secondary windings of input transformer **112** due to the interwinding capacitances and will produce an impedance drop in the secondary winding, which, assuming the same noise voltage direction as before, will be from terminal S_2 to S_1. A current is also set up at this same time through condenser **145** in the direction from terminal S_2 to terminal P_2. A part of this current will pass through the primary winding of input transformer **112** in a direction from terminal P_2 to P_1. This flow of current causes an impedance drop from terminal P_2 to P_1 which, by transformer action, will appear across the secondary winding as an impedance drop from terminal S_1 to S_2. This last-mentioned impedance drop will act to neutralize the impedance drop from terminal S_2 to S_1 arising, as explained above, from flow of the noise current in the secondary winding.

While specific embodiments of the invention have been selected for detailed description, the invention is not, of course, limited in its application to the embodiments disclosed. For example, the path to ground may include other types of networks than the capacity illustrated. In short, the embodiments described should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. In a transmission line including a transformer having a primary winding and a secondary winding and an inherent interwinding ca-

pacitance, a connection to ground for one terminal of said secondary winding, a variable condenser, one terminal of said variable condenser being connected to an external terminal of said primary winding, and selective means for connecting the other terminal of said variable condenser directly to ground or to ground through said one terminal of the secondary winding.

2. An input transformer for coupling a line to a vacuum tube repeater having a primary winding and a secondary winding, said primary winding having a first external terminal and a second external terminal, said secondary winding having a first external terminal corresponding to said first terminal of the primary winding and a second external terminal corresponding to said second terminal of the primary winding, said windings being in series-aiding relationship when connected from said first terminal of the primary to said second terminal of the primary to said second terminal of the secondary to said first terminal of the secondary, a connection to ground for an element of the vacuum tube repeater and said second terminal of the secondary winding and a connection to ground through a capacitance for said second terminal of said primary, said last-mentioned connection to ground being independent of said first-mentioned connection to ground.

3. An input transformer for coupling a line to a vacuum tube repeater having a primary winding and a secondary winding, said primary winding having a first external terminal and a second external terminal, said secondary winding having a first external terminal corresponding to said first terminal of the primary winding and a second external terminal corresponding to said second terminal of the primary winding, said windings being in series-aiding relationship when connected from said first terminal of the primary to said second terminal of the primary to said second terminal of the secondary to said first terminal of the secondary, a connection to ground for an element of the vacuum tube repeater and said second terminal of the secondary winding and a variable condenser, one terminal of said variable condenser being connected to ground independently of said connection to ground for the repeater element and said second terminal of the secondary winding and the other terminal of said variable condenser being connected to said second terminal of the primary winding.

4. In a transmission line subjected to longitudinal currents, a transformer having a primary winding and a secondary winding, said primary winding having a first external terminal and a second external terminal, said secondary winding having a first external terminal corresponding to said first terminal of the primary winding and a second external terminal corresponding to said second terminal of the primary winding, said windings being in series-aiding relationship when connected from said first terminal of the primary to said second terminal of the primary to said second terminal of the secondary to said first terminal of the secondary, and means for neutralizing the effect on said secondary winding of said longitudinal currents, said means comprising a connection to ground through a network for said second external terminal of said primary winding, said connection to ground being independent of said secondary winding.

5. In a transmission line subjected to longitudinal currents, a transformer having a primary winding and a secondary winding, said primary winding having a first external terminal and a second external terminal, said secondary winding having a first external terminal corresponding to said first terminal of the primary winding and a second external terminal corresponding to said second terminal of the primary winding, said windings being in series-aiding relationship when connected from said first terminal of the primary to said second terminal of the primary to said second terminal of the secondary to said first terminal of the secondary, and means for neutralizing the effect on said secondary winding of said longitudinal currents, said means comprising a path to ground through a variable condenser connected to said second external terminal of said primary winding, said path to ground being independent of said secondary winding.

6. In a transmission line subjected to longitudinal currents, a transformer having a primary winding, a secondary winding and an inherent interwinding capacitance, said interwinding capacitance resulting in passage of longitudinal currents from the primary winding to the secondary winding thereby causing a voltage drop in the secondary winding, means for establishing an independent flow of longitudinal currents through the primary winding to ground effective through transformer action to establish a voltage rise in the secondary of a magnitude and phase angle sufficient to offset said voltage drop therein.

7. In a transformer having a primary winding and a secondary winding, one of said windings being subjected to the passage of noise currents therethrough resulting in an impedance drop therein, means for establishing an independent flow of noise currents through the other of said windings to ground resulting in an impedance drop therein, the magnitude of said last-mentioned impedance drop being substantially the same as that of the first-mentioned impedance drop and its direction being opposite to that of the first-mentioned impedance drop.

8. In a transformer having a primary winding and a secondary winding, said secondary winding being subjected to the passage therethrough of longitudinal currents resulting in an impedance drop therein, means for establishing an independent flow of longitudinal currents through said primary winding to ground resulting in an impedance drop therein, the magnitude of said last-mentioned impedance drop being substantially the same as that of the first-mentioned impedance drop and its direction being opposite to that of the first-mentioned impedance drop.

9. In a transmission line subjected to longitudinal currents, a transformer having a primary winding, a secondary winding and an inherent interwinding capacitance, said interwinding capacitance resulting in passage of noise currents from one of said windings to the other, a first external terminal and a second external terminal for said primary winding, a first external terminal for said secondary winding corresponding to said first external terminal of said primary, a second external terminal for said secondary winding corresponding to said second terminal of said primary, and means for neutralizing the effect on one of said windings of passage of noise currents through the other of said windings, said means comprising a path to ground through a variable condenser connected to said second terminal of said primary winding, said windings being arranged to be in series-

aiding relationship when connected from said first terminal of said primary to said second terminal of said primary to said second terminal of said secondary to said first terminal of said secondary when said noise currents first occur in said primary windings and said windings being arranged to be in series-aiding relationship when connected from said first terminal of said primary to said second terminal of said primary to said first terminal of said secondary to said second terminal of said secondary when said noise currents first occur in said secondary winding.

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