May 12, 1942. E. R. TAYLOR 2,282,437

SPEECH TRANSMISSION SYSTEM

Filed Feb. 25, 1941 3 Sheets-Sheet 1

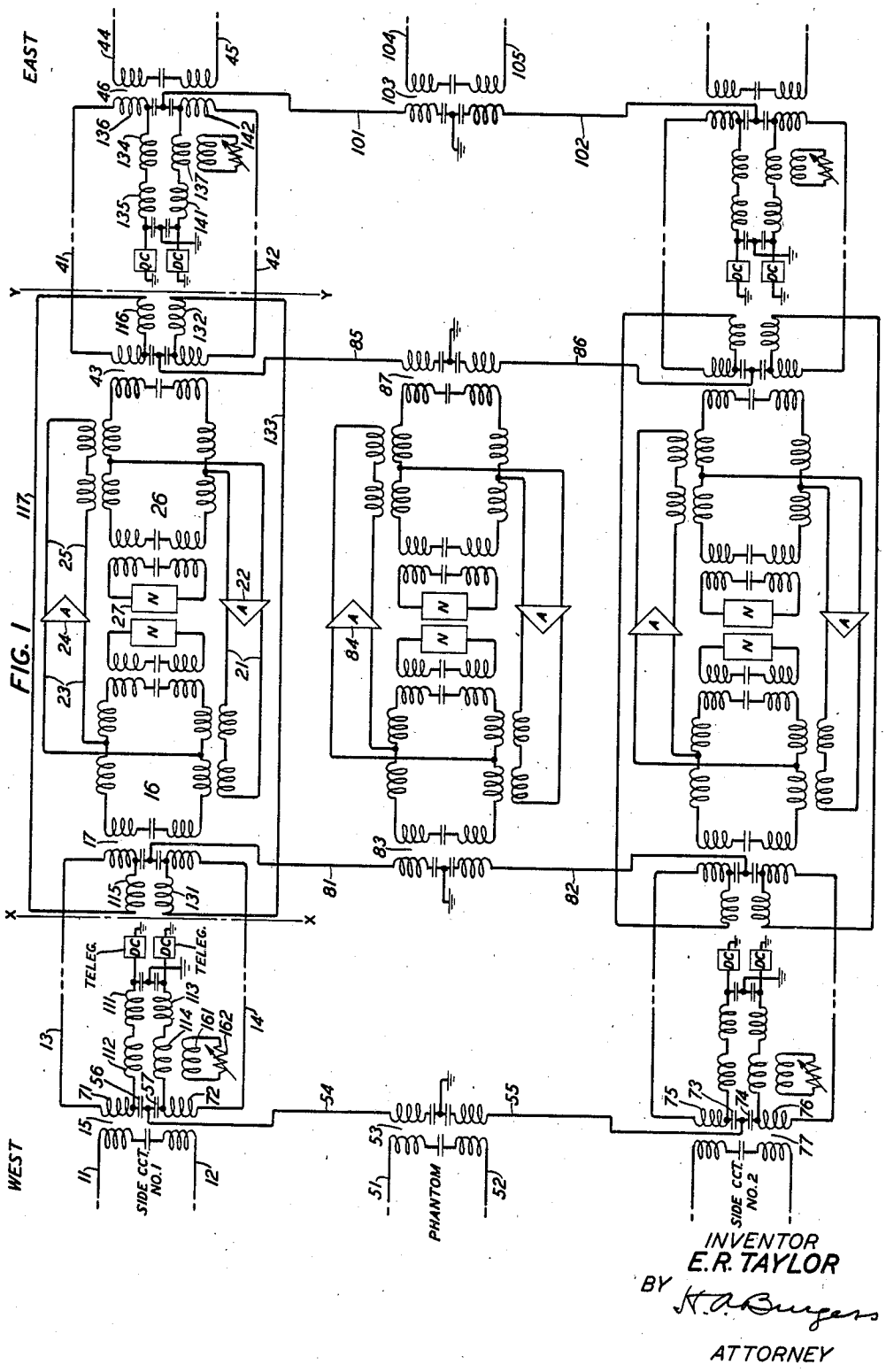

FIG. 1

INVENTOR
E.R. TAYLOR
BY H. A. Burgess
ATTORNEY

May 12, 1942. E. R. TAYLOR 2,282,437

SPEECH TRANSMISSION SYSTEM

Filed Feb. 25, 1941 3 Sheets-Sheet 2

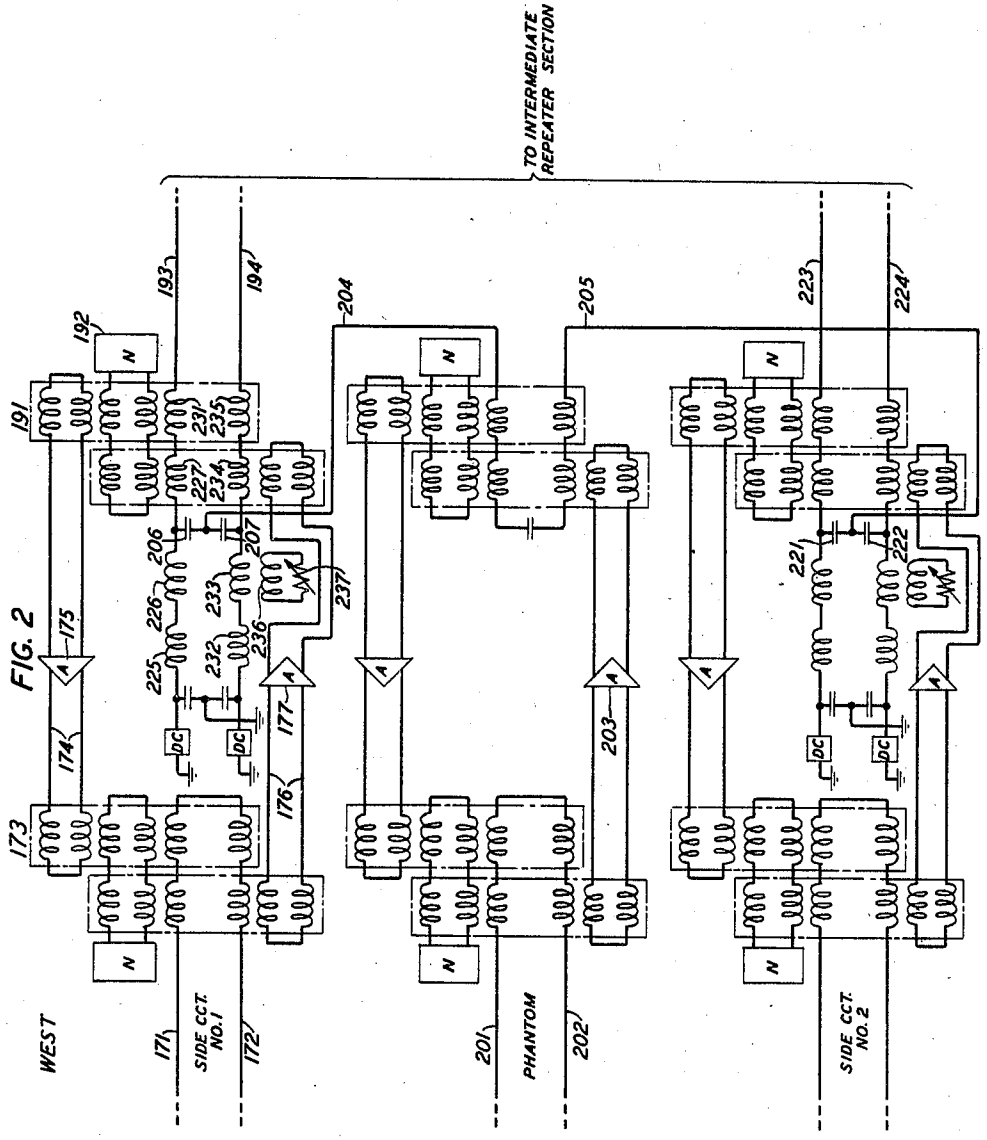

FIG. 2

INVENTOR
E. R. TAYLOR
BY W. A. Burgess
ATTORNEY

May 12, 1942. E. R. TAYLOR 2,282,437

SPEECH TRANSMISSION SYSTEM

Filed Feb. 25, 1941 3 Sheets-Sheet 3

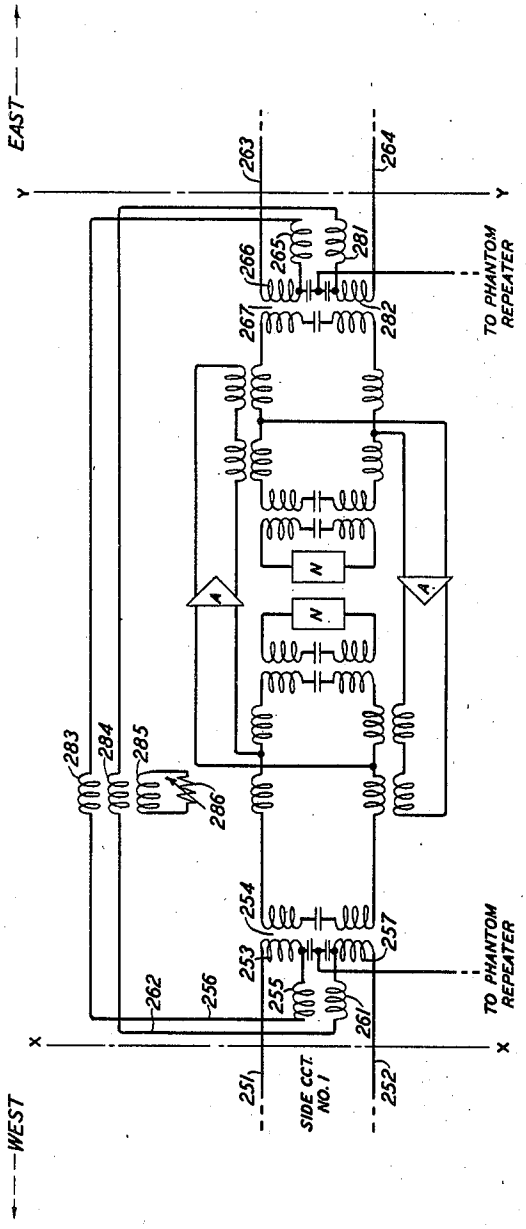

FIG. 3

INVENTOR
E. R. TAYLOR
BY N. A. Bruges
ATTORNEY

Patented May 12, 1942 2,282,437

UNITED STATES PATENT OFFICE

2,282,437

SPEECH TRANSMISSION SYSTEM

Edmund R. Taylor, Mount Vernon, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application February 25, 1941, Serial No. 380,461

9 Claims. (Cl. 179—3)

This invention relates to a speech transmission system of the type which includes telephone repeaters spaced at intervals along the transmission line and more particularly to such a system adapted to transmit, in addition to the speech currents, direct current signaling current.

An object of the invention is to increase the efficiency of speech transmission systems.

A more specific object of the invention is to prevent pulse distortion due to cross-fire resulting from application of direct current signaling current to the speech transmission lines.

A copending application in the name of applicant and another (P. G. Edwards) Serial No. 380,446, filed Feb. 25, 1941, entitled Speech transmission system, discloses, among other things, a novel way of applying direct current signaling currents to a speech transmission system and a novel arrangement for by-passing such signaling currents around intervening telephone repeaters. Briefly stated here, but described in detail in the copending application referred to, the telegraph direct current signaling currents are applied to the voice transmission lines in shunt with capacitances located between the line windings of the line repeating coil whereby the direct current composite sets are shunted by a low impedance at voice frequencies and the by-pass circuits are connected to the speech transmission lines in a similar manner. The arrangement contemplated by the present invention is particularly applicable to the above arrangements as fully disclosed by the copending application referred to.

A feature of the present invention is means, adaptable alike to the composite set connection or to the by-pass circuit for neutralizing the effect upon one set of coils of currents induced therein by the passage of telegraph direct current signaling currents through another set of coils.

A further feature of the present invention is adjustable means for varying the coupling between coils utilized in the neutralizing means in order to attain a more exact corrective factor.

In accordance with a specific embodiment of the invention a neutralizing or bucking inductance is provided in each leg of the direct current composite set in series with the respective retardation coils of the composite set. Signaling currents passing through either leg of the composite set will give rise through induction to current in the inductance of the other composite leg; this induced current is utilized to neutralize any disturbing current set up in the secondary of the line repeating coil by passage of the signaling currents referred to. Coupling between the two inductances is varied by means of a closed loop circuit comprising a third inductance and a variable resistance.

A complete understanding of the various novel arrangements contemplated by the present invention as well as appreciation of the various desirable features thereof will be gained by consideration of the following detailed description in connection with the annexed drawings in which:

Fig. 1 illustrates schematically a speech transmission system of the type utilizing line repeating coils and including cross-fire preventing means which embodies features of the present invention;

Fig. 2 illustrates schematically one terminal of a speech transmission system of the type utilizing combined line and hybrid coils and including cross-fire preventing means which embodies features of the present invention; and

Fig. 3 illustrates schematically a portion of the system of Fig. 1 modified to include cross-fire preventing means in the repeater by-pass.

Referring now to Fig. 1 there is illustrated schematically a speech transmission system including a west terminal, an intermediate repeater section and an east terminal. It will be understood that there may be, and in most cases will be, more than one intermediate repeater provided between the terminals.

Voice frequency currents produced by transmitting apparatus associated with terminal lines 11 and 12 of side circuit No. 1 are applied to lines 13 and 14 through repeating coil 15. These speech currents pass over lines 13 and 14 to the intermediate repeater section where they are impressed on line section 16 by repeating coil 17. One-half of the speech energy impressed on line section 16 passes through inductive coupling into output path 21 of east-west amplifier 22 and is lost; the useful half of the speech energy passes directly into input path 23 of west-east amplifier 24 and is amplified.

The amplified speech energy now present in west-east amplifier output path 25 is impressed on line section 26 where it again divides, one-half being absorbed by balancing network 27 and the useful half being impressed on lines 41 and 42 by repeating coil 43. The input circuit of east-west amplifier 22 is so bridged across line section 26 that its terminals are at equal potential with respect to output energy from west-east amplifier 24 so that none of this energy

works back through the input circuit to east-west amplifier 22.

The voice frequency currents pass over lines 41 and 42 to the east terminal where they are impressed on terminal lines 44 and 45 by repeating coil 46 and transmitted thereover to the voice frequency receiving apparatus associated with the east terminal.

It will be understood that transmission of voice frequency currents over side circuit No. 1 from east to west is accomplished in a manner similar to that described above as is transmission of voice frequency currents over side circuit No. 2 from west to east and from east to west.

Voice frequency currents produced by the voice frequency apparatus associated with lines 51 and 52 of the west phantom terminal are impressed through repeating coil 53 on the phantom circuit which is derived over lines 54 and 55. Line 54 terminates in side circuit No. 1 between capacitances 56 and 57 which, in turn, are connected in series with line windings 71 and 72 of repeating coil 15 while line 55 terminates in side circuit No. 2 between capacitances 73 and 74 which, in turn, are connected in series with line windings 75 and 76 of repeating coil 77.

Upon reaching the intermediate repeater secton, the phantom voice frequency currents are picked off over lines 81 and 82 and impressed by repeating coil 83 on the phantom intermediate repeater section. After amplification by phantom west-east amplifier 84 (in a manner similar to that described above in connection with transmission of speech currents over side circuit No. 1) the amplified currents are impressed on lines 85 and 86 by repeating coil 87 and returned thereover to the phantom circuit for transmission to the east terminal.

Upon reaching the east terminal, the phantom voice frequency currents are picked off over lines 101 and 102 and impressed by repeating coil 103 on phantom terminal lines 104 and 105 over which they are transmitted to the voice frequency receiving apparatus associated with the east phantom terminal.

It will be understood that transmission of voice frequency currents over the phantom circuit from east to west is accomplished in a manner similar to that described above.

Direct current signals, for example telegraph signals, are impressed on line 13 at the west terminal through retardation coil 111 and bucking coil 112 which are connected in series with repeating coil line winding 71 and are impressed on line 14 through retardation coil 113 and bucking coil 114 which are connected in series with repeating coil line winding 72.

At the intermediate repeater section these direct current signals are by-passed around the amplifiers over a by-path which comprises retardation coils 115 and 116 and line 117 and retardation coils 131 and 132 and line 133. Upon reaching the east terminals the direct current signals are transmitted to the direct current receiving apparatus associated with the east terminal through bucking coil 134 and retardation coil 135 which are connected in series with repeating coil line winding 136 and through bucking coil 137 and retardation coil 141 which are connected in series with repeating coil line winding 142.

It will be understood that transmission of direct current signals over side circuit No. 1 from east to west as well as transmission of such signals over side circuit No. 2 in both directions is accomplished in a manner similar to that described above.

In the absence of the bucking or neutralizing coil arrangement, which is the essence of the present invention, it has been found that passage of the direct current signals through the line windings of the repeating coils causes pulse distortion due to so-called "cross-fire." Cross-fire is a term commonly used by communication engineers when referring to interfering currents set up in one circuit, particularly a telegraph circuit, due to the passage of direct current signals through a paralleling circuit. The bucking or neutralizing coil arrangement of the present invention is effective in eliminating this trouble.

Referring again to the west terminal of side circuit No. 1 and assuming for the moment the absence of the bucking coils, it has been found that the direct current signals impressed on line 13 set up by induction, when passing through line winding 71, currents in line winding 72 which, when uncorrected, result in signal distortion. With provision of the bucking coils, however, passage of the direct current signals through bucking or neutralizing coil 112 and line winding 71 set up voltages respectively in bucking coil 114 and line winding 72 by induction. (It will be understood that coils 112 and 114 have a common core and that line windings 71 and 72 have a common core.) Now, bucking coil 114 and line winding 72 are so poled with respect to one another that the voltages induced therein tend to neutralize each other, the net result being, therefore, that no disturbing voltages persist in line winding 72 due to the application of direct current signals to line 13.

In order that a more exact neutralization may be attained a closed conductive loop is provided which comprises inductance 161 and variable resistance 162 connected in series, inductance 161 being inductively associated with bucking coils 112 and 114. Variation of resistance 162 permits control of the coupling between coils 112 and 114 whereby the magnitude of the voltages induced in coil 114 by passage of direct current through coil 112 may be fixed at the exact desired value.

It will be understood that the arrangement functions in a similar manner with respect to direct current signals applied to line 14. In such instance passage of the direct current signals through bucking coil 114 and line winding 72 set up voltages by induction in bucking coil 112 and line winding 71 respectively. Bucking coil 112 and line winding 71 are so poled with respect to each other that the induced voltages tend to neutralize one another.

It will be understood, further, that the bucking coil arrangements of the east terminal of side circuit No. 1 and those of the west and east terminals of side circuit No. 2 function in a manner similar to that described above.

Referring now to Fig. 2 there is illustrated the west terminal of a speech transmission system of the type utilizing combined line and hybrid coils. It will be understood that the arrangement of the east terminal will be similar to that of the west terminal illustrated and that one or more intermediate repeater sections may be included in the system. A complete system of this general nature is disclosed in the copending application of applicant and another referred to above.

Voice frequency currents impressed on lines 171 and 172 by the speech transmitting equip-

ment associated with side circuit No. 1 at the west terminal divide in the windings of hybrid coils 173, one-half of the energy passing into output path 174 of east-west amplifier 175 and being lost and the useful half passing into input path 176 of west-east amplifier 177. After amplification these voice frequency currents again divide in the windings of hybrid coils 191, one-half of the energy being absorbed by balancing network 192 and the useful half passing into lines 193 and 194 for transmission to the east terminal or to the next intermediate repeater section. In view of the fact that the output path of west-east amplifier 177 and the input path of east-west amplifier 175 are coupled in conjugate relationship through the windings of hybrid coils 191, no part of the amplified output of west-east amplifier 177 is fed back into the input path of east-west amplifier 175.

Voice frequency currents are transmitted over side circuit No. 2 in a manner similar to that described above while voice frequency currents impressed on phantom line sections 201 and 202, after amplification by phantom west-east amplifier 203, are transmitted over a phantom circuit derived over lines 204 and 205. Line 204 terminates in side circuit No. 1 between capacitances 206 and 207 which are connected, in turn, across lines 193 and 194 while line 205 terminates in side circuit No. 2 between capacitances 221 and 222 which are connected, in turn, across lines 223 and 224.

Direct current signals, for example telegraph signals, are applied to line 193 through retardation coil 225, bucking or neutralizing coil 226 and line windings 227 and 231 of hybrid coils 191 in series and are applied to line 194 through retardation coil 232, bucking coil 233 and line windings 234 and 235 of the hybrid coils in series. In this arrangement, as in the arrangement of Fig. 1 described above, it has been found that, in the absence of the bucking coil arrangement, passage of the direct current signals through the line windings causes pulse distortion due to so-called cross-fire. The bucking coil arrangement is effective in eliminating this trouble in the circuit of Fig. 2 in a manner similar to that described above in connection with Fig. 1.

Assuming for the moment the absence of the bucking coils, it has been found that the direct current signals impressed on line 193 set up by induction, when passing through line windings 227 and 231, currents in line windings 234 and 235, which, when uncorrected, result in signal distortion. With the provision of the bucking coil arrangement, however, passage of the direct current signals through bucking coil 226 and line windings 227 and 231 set up voltages in bucking coil 233 and in line windings 234 and 235 respectively by induction. Bucking coil 233 is so poled with respect to line windings 234 and 235 that the voltages set up in the bucking coil neutralize those set up in the line windings, the net result being that no disturbing voltages persist in line windings 234 and 235 due to the application of the direct current signals to line 193.

As in the instance of the arrangement described above a closed conductive loop, comprising inductance 236 and variable resistance 237 connected in series, is provided to permit the attainment of a more exact neutralization.

It will be understood that the arrangement functions in a similar manner with respect to direct current signals applied to line 194. In such instance the direct current signals passing through bucking coil 233 and line windings 234 and 235 set up voltages by induction in bucking coil 226 and in line windings 227 and 231 respectively. Bucking coil 226 is so poled with respect to line windings 227 and 231 that the voltages induced in the line windings are neutralized by those induced in the bucking coil.

There is illustrated in Fig. 3 the intermediate repeater section of side circuit No. 1 of a system which is the same as that illustrated in Fig. 1 except for the fact that the bucking coil arrangement has been provided in the by-pass circuit also. In view of the fact that the system is otherwise as illustrated in Fig. 1 and described in detail above, it has not been considered necessary to illustrate the complete system and its operation will be described only in so far as action of the bucking coil arrangement in the by-pass circuit is concerned.

Direct current signals (telegraph) arriving at the intermediate repeater station of side circuit No. 1 over lines 251 and 252 pass respectively through line winding 253 of repeating coil 254 and retardation coil 255 to line 256 and through line winding 257 of repeating coil 254 and retardation coil 261 to line 262. The direct current signals are by-passed around the intermediate repeater section over lines 256 and 262, and through bucking or neutralizing coils 283 and 284 and are reapplied to lines 263 and 264 through retardation coil 265 and line winding 266 of repeating coil 267 and through retardation coil 281 and line winding 282 of repeating coil 267, respectively.

In the absence of the bucking coil arrangement of the present invention it has been found that signal distortion due to cross-fire has resulted from passage of the direct current signals through the line windings of the repeating coil. Assuming first the absence of the bucking coils, the direct current signals passing through line winding 253 of the repeating coil will set up disturbing voltages in line winding 257 through inductance. With the provision of the bucking coil arrangement, however, direct current signals passing through line winding 253 and bucking or neutralizing coil 283 will set up voltages by induction in line winding 257 and bucking coil 284, respectively. Bucking coil 284 is so poled with respect to line winding 257 that the voltages induced in the bucking coil neutralize those induced in the line winding, the net result being that no disturbing voltages persist in line winding 257 due to the passage of direct current signals through line winding 253.

As in the instance of the bucking coil arrangements described above a closed conductive loop, comprising inductance 285 and variable resistance 286 connected in series, is provided for the attainment of a more exact neutralization.

It will be understood that the bucking coil arrangement functions in a similar manner with respect to direct current signals passing through line winding 257. In such instance, the direct current signals passing through line winding 257 and bucking coil 284 will set up voltages by induction in line winding 253 and bucking coil 283. Bucking coil 283 is so poled with respect to line winding 253 that the voltages induced in the bucking coil will neutralize those induced in the line winding, the net result being that no disturbing voltages persist in line winding 253 due to the passage of direct current signals through line winding 257.

It will be understood that the bucking coil

arrangement may be designed to also prevent the establishment of disturbing voltages in the line windings of repeating coil **267** or that, if desirable, a separate set of bucking coils may be associated with that repeating coil.

While certain specific embodiments of the invention have been selected for illustration and detailed description, the invention is not, of course, limited in its application to such embodiments. The embodiments described should be looked upon as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. In a speech transmission system, a terminal section, a two-wire line, a repeating coil for connecting said terminal section and said line, a composite set for transmission of direct current signals, the secondary of said repeating coil including two inductive winding portions of high impedance to voice frequencies and a portion of low impedance to voice frequencies but of high impedance to direct current, means for connecting the two legs of said composite set across said latter portion, means for neutralizing any disturbing effects set up in the windings of said repeating coil by passage therethrough of currents transmitted by said composite set, said neutralizing means including a winding connected in series with each leg of said composite set, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings.

2. In a speech transmission system, a terminal section, a two-wire line, a repeating coil for connecting said terminal section and said line, a composite set for transmission of direct current signals, the secondary of said repeating coil including two inductive winding portions of high impedance to voice frequencies and a portion of low impedance to voice frequencies but of high impedance to direct current, means for connecting the two legs of said composite set across said latter portion, means for neutralizing any disturbing effects set up in the windings of said repeating coil by passage therethrough of currents transmitted by said composite set, said neutralizing means including a neutralizing winding connected in series with each leg of said composite set, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings, said last-mentioned means including a closed conductive loop comprising a winding and a variable resistance connected in series, said last-mentioned winding being inductively coupled to said neutralizing windings.

3. In a speech transmission system, a west terminal, an east terminal, and a two-wire line for connecting said west and said east terminals, a two-way repeater for voice frequencies at said west terminal, a hybrid coil and balancing network at said west terminal for connecting said line to two sides of said repeater in mutually conjugate relationship, a line winding of said hybrid coil being connected in series with each side of said two-wire line, means at said west terminal for applying direct current signals to each side of said two-wire line in series respectively with said line windings of said hybrid coil, means for neutralizing disturbing effects induced in one of said line windings by passage of direct current signals through the other of said line windings, said means comprising a neutralizing winding connected in series with each side of said two-wire line between the respective line windings and the respective points of application of the direct current signals, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings.

4. In a speech transmission system, a west terminal, an east terminal, and a two-wire line for connecting said west and said east terminals, a two-way repeater for voice frequencies at said west terminal, a hybrid coil and balancing network at said west terminal for connecting said line to two sides of said repeater in mutually conjugate relationship, a line winding of said hybrid coil being connected in series with each side of said two-wire line, means at said west terminal for applying direct current signals to each side of said two-wire line in series respectively with said line windings of said hybrid coil, means for neutralizing disturbing effects induced in one of said line windings by passage of direct current signals through the other of said line windings, said means comprising a neutralizing winding connected in series with each side of said two-wire line between the respective line windings and the respective points of application of the direct current signals, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings, said last-mentioned means including a closed conductive loop comprising a winding and a variable resistance connected in series, said last-mentioned winding being inductively coupled to said neutralizing windings.

5. In a speech transmission system, a west terminal, an intermediate repeater section, an east terminal, a first two-wire line for connecting said west terminal and said intermediate section, a second two-wire line for connecting said intermediate section and said east terminal, means at said west terminal for applying voice frequency currents to said first two-wire line, means at said west terminal for applying direct current signals to both sides of said first two-wire line, a two-way repeater for voice frequency currents at said intermediate repeater section, conductive means connected across the intermediate repeater section end of each of said two-wire lines, each of said conductive means comprising two portions of high impedance to voice frequencies connected by a portion of low impedance to voice frequencies but of high impedance to direct currents, a by-pass path at said intermediate repeater section for by-passing direct current signals from said first two-wire line around said two-way repeater to said second two-wire line, said by-pass path comprising two lines and being connected across said respective portions of low impedance to voice frequencies of said conductive means, means in said by-pass path for neutralizing any disturbing effects that may be set up in one part of the direct current path by passage of direct current signals through another part of the direct current path, said neutralizing means comprising a neutralizing winding connected in series with each of said lines of said by-pass path, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings.

6. In a speech transmission system, a west terminal, an intermediate repeater section, an east terminal, a first two-wire line for connecting said west terminal and said intermediate section, a second two-wire line for connecting said intermediate section and said east terminal, means at

said west terminal for applying direct current signals to both sides of said first two-wire line, a two-way repeater for voice frequency currents at said intermediate repeater section, conductive means connected across the intermediate repeater section end of each of said two-wire lines, each of said conductive means comprising two portions of high impedance to voice frequencies connected by a portion of low impedance to voice frequencies but of high impedance to direct currents, a by-pass path at said intermediate repeater section for by-passing direct current signals from said first two-wire line around said two-way repeater to said second two-wire line, said by-pass path comprising two lines and being connected across said respective portions of low impedance to voice frequencies of said conductive means, means in said bypass path for neutralizing any disturbing effects that may be set up in one part of the direct current path by passage of direct current signals through another part of the direct current path, said neutralizing means comprising a neutralizing winding connected in series with each of said lines of said by-pass path, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings, said last-mentioned means including a closed conductive loop comprising a winding and a variable resistance connected in series, said last-mentioned winding being inductively coupled to said neutralizing windings.

7. In a speech transmission system, a terminal section, a repeater section, a two-wire line for connecting said terminal section and said repeater section, a composite set for transmission of direct current signals, said composite set including two conductive legs, conductive means connected across the terminal section end of said two-wire line, said conductive means comprising a first inductance, a capacitance and a second inductance connected in series in the order named, means for connecting one of said legs of the composite set to said conductive means at the junction of said first inductance and said capacitance, means for connecting the other of said legs of the composite set to said conductive means at the junction of said capacitance and said second inductance whereby direct current signals transmitted over the first leg will pass through said first inductance to one side of said two-wire line and direct current signals transmitted over the second leg will pass through said second inductance to the other side of said two-wire line, and means included in said composite set for neutralizing any disturbing effects set up in one of said inductances by passage of direct current signals through the other of said inductances.

8. In a speech transmission system, a terminal section, a repeater section, a two-wire line for connecting said terminal section and said repeater section, a composite set for transmission of direct current signals, said composite set including two conductive legs, conductive means connected across the terminal section end of said two-wire line, said conductive means comprising a first inductance, a capacitance and a second inductance connected in series in the order named, means for connecting one of said legs of the composite set to said conductive means at the junction of said first inductance and said capacitance and means for connecting the other of said legs of the composite set to said conductive means at the junction of said capacitance and said second inductance whereby direct current signals transmitted over the first leg will pass through said first inductance to one side of said two-wire line and direct current signals transmitted over the second leg will pass through said second inductance to the other side of said two-wire line, means included in said composite set for neutralizing any disturbing effects set up in one of said inductances by passage of direct current signals through the other of said inductances, said neutralizing means including a neutralizing winding connected in series with each leg of said composite set, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings.

9. In a speech transmission system, a terminal section, a repeater section, a two-wire line for connection said terminal section and said repeater section, a composite set for transmission of direct current signals, said composite set including two conductive legs, conductive means connected across the terminal section end of said two-wire line, said conductive means comprising a first inductance, a capacitance and a second inductance connected in series in the order named, means for connecting one of said legs of the composite set to said conductive means at the junction of said first inductance and said capacitance and means for connecting the other of said legs of the composite set to said conductive means at the junction of said capacitance and said second inductance whereby direct current signals transmitted over the first leg will pass through said first inductance to one side of said two-wire line and direct current signals transmitted over the second leg will pass through said second inductance to the other side of said two-wire line, means included in said composite set for neutralizing any disturbing effects set up in one of said inductances by passage of direct current signals through the other of said inductances, said neutralizing means including a neutralizing winding connected in series with each leg of said composite set, said neutralizing windings being inductively coupled, and means for varying the closeness of the coupling of said neutralizing windings, said last-mentioned means including a closed conductive loop comprising a winding and a variable resistance connected in series, said last-mentioned winding being inductively coupled to said neutralizing windings.

EDMUND R. TAYLOR.