Jan. 16, 1923.

1,442,425.

R. D. CONWAY.

TELEPHONE REPEATER SYSTEM.

FILED DEC. 27, 1918.

2 SHEETS—SHEET 1.

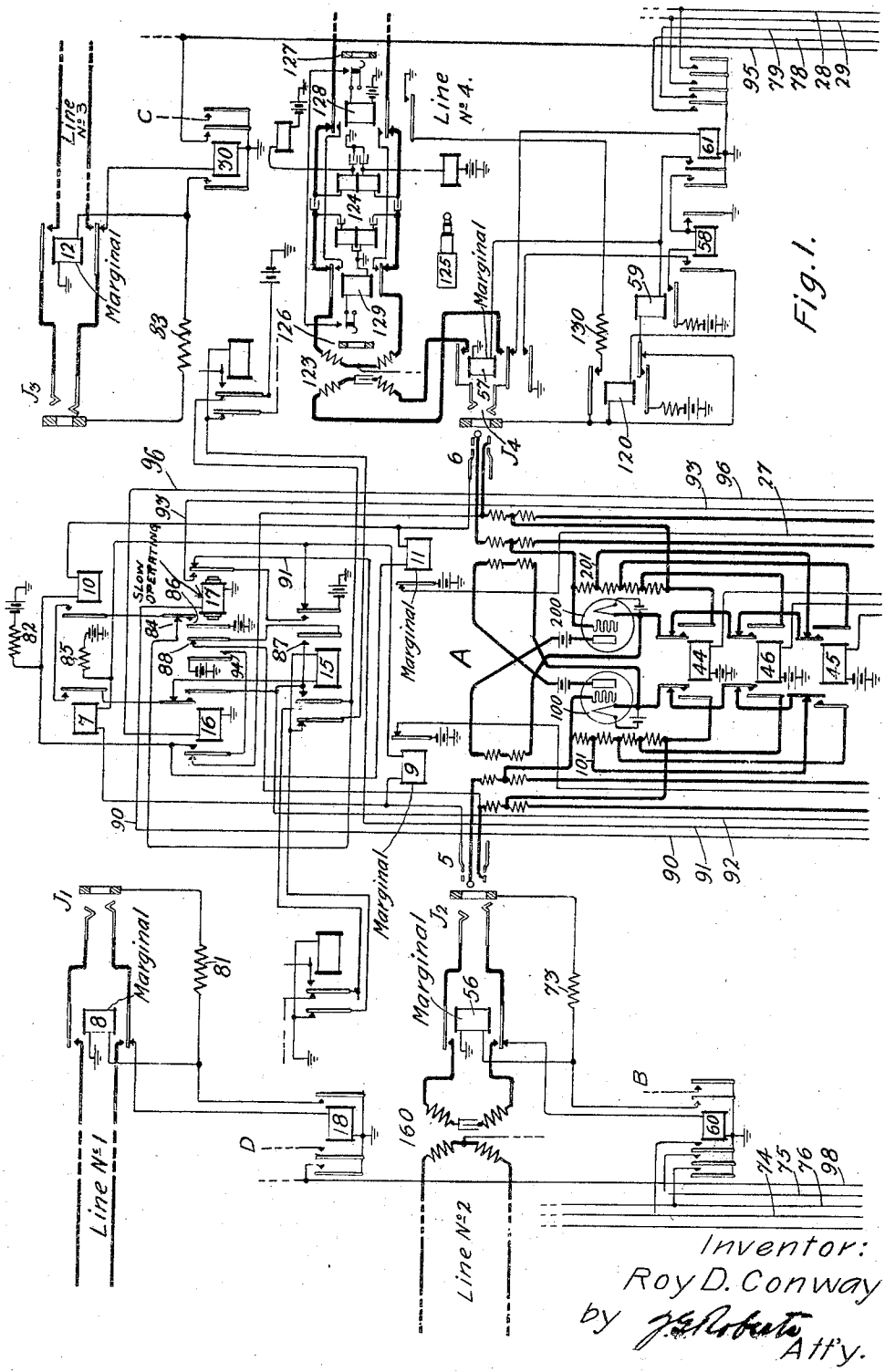

Fig. 1.

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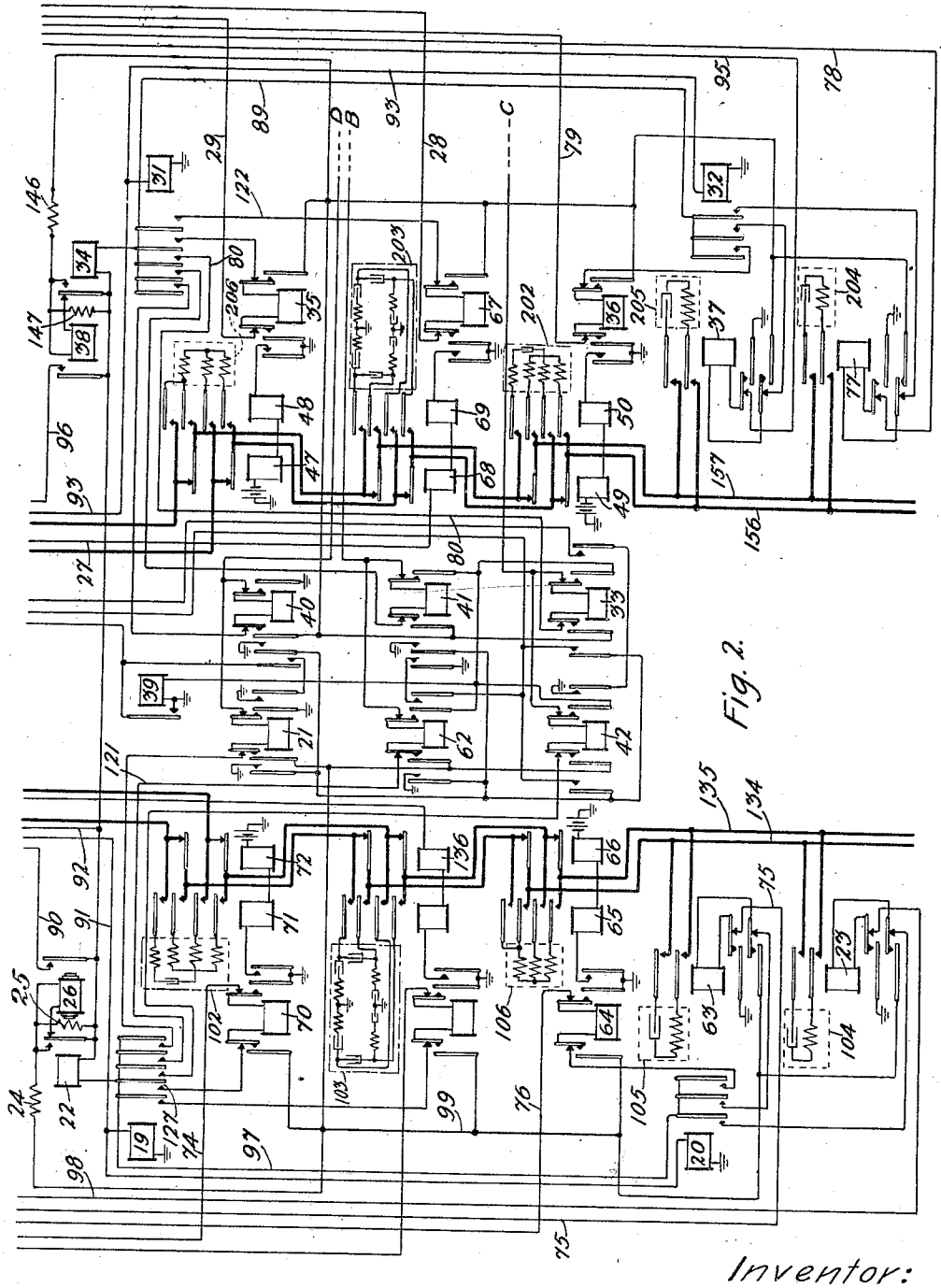

Fig. 2.

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Patented Jan. 16, 1923. 1,442,425

UNITED STATES PATENT OFFICE.

ROY D. CONWAY, OF CHATHAM, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE REPEATER SYSTEM.

Application filed December 27, 1918. Serial No. 268,466.

To all whom it may concern:

Be it known that I, ROY D. CONWAY, a citizen of the United States, residing at Chatham, in the county of Morris, State of New Jersey, have invented certain new and useful Improvements in Telephone Repeater Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone repeater systems, and more particularly to such systems in which connecting circuits for joining telephone lines are equipped with repeaters or amplifiers for amplifying talking currents.

In systems of this character the telephone lines terminating at a particular central office may be differently equipped for various kinds of service, and may vary in impedance. For example, some lines may form sides of phantom circuits, and when so employed are equipped with phantoming apparatus; other lines may be equipped with composite apparatus for permitting the simultaneous transmission of both telegraphic or signaling and telephonic currents over the same line, and still other lines may be equipped with both phantoming and composite apparatus. When a repeater is associated with any telephone line, it is usual to associate with the repeater an artificial balancing line or network (or several such networks) whose impedance simulates that of the telephone line.

It is an object of this invention to provide in such systems improved means and methods for automatically selecting and associating balancing networks with a repeater, when the repeater is connected with the telephone line.

In systems of this character it is also usual to provide means for disconnecting composite apparatus from the telephone line with which it is associated, and if this disconnection takes place when a repeater is associated with a telephone line, it is important that the composite balancing apparatus or network be disconnected at the same time. It is therefore another object of this invention to provide improved means for so automatically disconnecting the composite balancing network whenever the composite apparatus is disconnected, whereby the telephone line with which the repeater is associated may be maintained in a balanced condition.

In accordance with the various features of this invention, each telephone line is provided with selection-control apparatus operating upon the connection of the central office connecting circuit with a terminal of the telephone line, and cooperating with selection-control apparatus in the connecting circuit to control the selection of the proper balancing network or networks, and the association of the selected networks with the repeater in the connecting circuit, and additional apparatus associated with the telephone line and connecting circuit, is rendered effective when the selected networks are associated with the repeater to disconnect the line selection-control apparatus from the telephone line. The disconnection of the composite apparatus from the telephone line, while associated with the repeater connecting circuit, causes the operation of marginal control apparatus provided in the connecting circuit whereby the composite balancing network is automatically and simultaneously disconnected from the repeater.

For a more complete understanding of this invention, reference should be had to the following description considered in connection with the accompanying drawings, which, with Fig. 1 arranged immediately above Fig. 2, illustrate one embodiment of this invention.

Referring to the drawings, there are shown telephone lines Nos. 1, 2, 3 and 4, lines Nos. 1 and 3 having different impedances and requiring different types of balancing networks, line No. 2 being equipped with phantoming apparatus 160, and line No. 4 being equipped with both phantoming apparatus 123 and composite apparatus 124. A connecting circuit A equipped with two repeaters or amplifiers 100 and 200, one of which amplifies telephone currents in one direction and the other in the opposite direction, is provided at the central office.

Potentiometers 101 and 201 are associated with the input circuits of the amplifiers 100 and 200 for controlling the gain of the respective amplifiers. For controlling the adjustment of these potentiometers there are provided three potentiometer-control re-

lays 44, 45 and 46, controlled by the telephone lines with which the connecting circuit A is associated. Circuits of the potentiometer-control relays are controlled in such a manner that if one telephone line requires a certain gain, and the other line with which it is connected by means of the connecting circuit A requires a greater gain, then one or more of the three potentiometer-control relays will be operated to adjust the potentiometers to give a gain which is approximately the mean of that required by the two connected telephone lines whereby the transmission efficiency in one direction is approximately equal to that in the other direction. The potentiometer adjusting relays 44, 45 and 46 are governed by intermediate control relays 21, 33, 39, 40, 41, 42 and 62 connected with the leads B, C and D. Depending upon the gain required for a particular line, one of these leads or no lead is connected with a contact of the line selection control relays of that line. Each of the leads after passing through the windings of the proper intermediate relays, is multipled to contacts of the cord selection control relays.

In order that the different telephone lines, with which the connecting circuit may be associated, may be properly balanced, there are provided for association with each of the amplifiers various balancing networks in accordance with the requirements of the different types of lines. For association with the respective amplifiers there are provided phantom balancing networks 102 and 202, composite balancing networks 103 and 203, basic networks 104 and 105 (of different impedances) and 204, 205 (of different impedances), and building-out sections (networks) 106 and 206. A basic network is one which is always employed in balancing a telephone line regardless of its impedance. There may be different types of basic networks according to the value of their impedance. For example, a certain type of network may be employed in balancing lines, all having impedances up to a certain value; another type may be employed for balancing telephone lines having impedances falling within certain predetermined limits. If the impedance of a line is greater than that of the basic network, then a building-out section, whose impedance compensates for the difference, is employed, and both basic network and the building-out section are selected and connected with the repeater for balancing the telephone line. For convenience, only a limited number of balancing networks are shown in the drawings, but it should be understood that in practice a larger number may be employed,—the number, or course, being determined by the number of telephone lines terminating at the central office.

The connection of these networks with the repeaters is controlled by relays whose selection is in turn controlled by a selection-control relay associated with each line (see relay 18 in line 1, relay 60 in line 2, relay 30 in line 3 and relay 61 in line 4) and cooperating selection-control relays in the connecting circuits (see relays 19 and 20 in one end and relays 31 and 32 in the other end). These selection-control relays control a set of intermediate control relays 21, 33, 39, 40, 41, 42 and 62 for determining which (if any) of the potentiometer adjusting relays are to be operated.

In order that the selecting apparatus of only one cord circuit may be effective at a time for selecting networks common to a plurality of cord circuits and telephone lines, there is provided in each cord circuit a master relay 15. The circuit of each master relay is controlled by all other such relays, and when one is energized, the energizing circuits of all other master relays are open. This is brought about by having a common battery lead extend in one direction through series contacts of all master relays, and a common ground extend in the opposite direction through other series contacts of the master relays.

With this short description of the system in mind, this invention may be clearly understood from a description of the operation of the system disclosed in the drawing. It will be assumed that line #1 is to be connected with line #3. The central office operator will therefore insert plug 5 into jack J^1 of line #1, and plug 6 into jack J^3 of line #3. The connection of the plug 5 with the jack J^1 causes the operation of relays 7 and 8 over a circuit from battery through the right-hand normal contact of master relay 15, windings of relays 7 and 9 in parallel, sleeve contact of the plug 5 and the jack J^1, resistance 81 and the winding of relay 8 to ground. Relay 9 is marginal and does not operate at this time. The insertion of the plug 6 into the jack J^3 of line #3 causes the operation of relay 10 over a circuit from battery through resistance 82, windings of relays 10 and 11 in parallel, sleeve contact of the plug 6 and the jack J^3, resistance 83 and the winding of relay 12 to ground. Relays 11 and 12 are marginal and do not operate at this time.

If the apparatus of no other cord circuit is selecting at this time, the master relay 15 of cord circuit A will be operated over a circuit from battery through the normal contacts of master relays in other cord circuits, contact 84 of slow-operating switching relay 17, contact of relay 10, contact of relay 7, right-hand normal contact of switching relay 16, winding of master relay 15 of cord circuit A, and contacts of master relays in other cord circuits to ground. The

opening of the right-hand normal contact of master relay 15 removes the short circuit of resistance 85, whereupon this resistance is included in circuit with relays 7, 8 and 9, and relay 8 releases, this relay being marginal and not holding up in series with the resistance 85 nor energizing in series with this resistance.

Upon the operation of the master relay 15 and the release of marginal relay 8, line selection control relay 18 associated with line #1 operates over a circuit from battery through the contacts of other master relays, left-hand and middle alternate contacts of master relay 15 of cord circuit A, contact 88 of switching relay 17, ring contacts of the plug 5 and jack J^1, lower-normal contact of marginal relay 8 and the winding of line selection control relay 18 to ground. The operation of the master relay 15 also causes the operation of selection-control relays 19 and 20 associated with the cord circuit A, these relays operating over a circuit from battery through the right-hand alternate contact of master relay 15, the right-hand normal contact of switching relay 17, conductor 91 and the windings of selection-control relays 19 and 20 in parallel to ground. The operation of selection-control relays 18 and 19 causes the operation of relays 21 and 22 over a circuit from battery through contacts of master relays of other cord circuits, the left-hand alternate contact of master relay 15, conductor 92, winding of relay 22, right-hand contact of selection-control relay 19, left-hand normal contact, winding and right-hand normal contact of relay 21, conductor D and the middle contact of selection-control relay 18 to ground. Relay 21 in operating completes a locking circuit for itself from battery over conductor 92, alternate contact of relay 22, resistance 24, an alternate contact winding and another alternate contact of relay 21 to ground. The operation of selection-control relays 18 and 20 causes the operation of relay 23 over a circuit from battery, over conductor 92, winding of relay 22, conductor 97, left-hand contact of relay 20, lower normal contact winding and upper normal contact of relay 23, conductor 98, and left-hand contact of selection-control relay 18 to ground. Relay 23 in operating completes a locking circuit for itself from battery over conductor 92, alternate contact of relay 22, resistance 24, conductor 99, an alternate contact and winding and another alternate contact of relay 23 to ground. Relay 23, in closing its upper alternate contacts, connects the basic network 104 with conductors 134 and 135, and through these conductors and the normal contacts of relays 66, 136 and 72, with the repeater 100 for balancing the line #1.

The locking up of relays 21 and 23 opens the energizing circuit of relay 22, whereupon this relay releases its armature and establishes an operating circuit for relay 26, which now operates. Resistance 25 is connected around the alternate contact of relay 22 to prevent the release of relays 21 and 23 while the armature of relay 22 is moving from its alternate to its normal contact. The operating circuit for this relay 26 may be traced from battery over conductor 92, normal contact of relay 22, winding of relay 26 and resistance 25 in parallel, resistance 24 and windings of relays 21 and 23 in parallel to ground. The operation of relay 26 causes the operation of slow-operating relay 17 over a circuit from battery, over conductor 92, contact of relay 26, conductor 90 and the winding of relay 17 to ground.

The operation of the switching relay 17 opens contact 84 in the energizing circuit of master relay 15, but before doing so, establishes an alternate holding circuit therefor from battery, through contact 86 of switching relay 17, contacts of relays 10 and 7, right-hand normal contact of relay 16, winding of master relay 15 and contacts of master relays of other cord circuits, to ground. The operation of switching relay 17 opens its right-hand normal contact in the energizing circuit of cord circuit selection-control relays 19 and 20, which thereupon release. Switching relay 17 in opening its contact 88, opens the energizing circuit of line selection control relay 18, which thereupon releases. The closure of contact 94 of switching relay 17 causes the operation of line selection control relay 30 of line #3 over a circuit from battery, through contact 94 of switching relay 17, left-hand normal contact of switching relay 16, ring contacts of the plug 6 and the jack J_3, lower normal contact of marginal relay 12, and the winding of line selection control relay 30 to ground. The closure of the right-hand alternate contact of switching relay 17 causes the operation of selection-control relays 31 and 32 over a circuit from battery, through the right-hand alternate contacts of master relay 15 and switching relay 17, conductor 93, and the windings of relays 31 and 32 in parallel to ground.

The operation of selection-control relays 30 and 31 causes the operation of relays 33 and 34 over a circuit from battery, over conductor 92, winding of relay 34, a contact of selection-control relay 31, conductor 80, a normal contact and winding and another normal contact of relay 33, conductor C, and the right-hand contact of selection-control relay 30 to ground. Relay 33 in operating completes a locking circuit for itself from battery, over conductor 92, alternate contact of relay 34, resistance 146, an alternate contact and winding and another alternate of relay 33, and winding of relay 39

to ground. Relay 39 in operating causes the operation of potentiometer-control relay 45, which changes the adjustment of both potentiometers.

The operation of selection-control relays 30 and 32 before referred to, causes the operation of relay 37 over a circuit from battery, over conductor 92, winding of relay 34, conductor 89, middle contact of selection-control relay 32, lower normal contact winding and upper normal contact of relay 37, conductor 95 and middle contact of line selection control relay 30 to ground. Relay 37 in operating completes a locking circuit for itself from battery, over conductor 92, alternate contact of relay 34, resistance 146, an alternate contact and winding and another alternate contact of relay 37 to ground. The operation of relay 37 connects basic network 205 to conductors 156 and 157, and through these conductors and the contacts of relays 49, 68 and 47 with repeater 200 for balancing line #3. Upon the energization and locking-up of relays 33 and 37, relay 34 releases, thereby opening its alternate and closing its normal contacts. Resistance 147 is connected around the alternate contact of relay 34 to prevent the release of relays 33 and 37 while the armature of relay 34 is moving from its alternate to its normal contact. Upon the closure of the normal contact of relay 34, relay 38 operates over a circuit from battery, over conductor 92, normal contact of relay 34, winding of relay 38 and resistance 147 in parallel, resistance 146, the windings of relays 33 and 37 in parallel, and the winding of relay 39 to ground. The operation of relay 38 causes the operation of switching relay 16 over a circuit from battery, over conductor 92, contact of relay 38, conductor 96 and the winding of switching relay 16 to ground.

The operation of switching relay 16, by opening its right-hand normal contact, opens the circuit of master relay 15 and causes the release thereof, but before this circuit is opened, a holding circuit for the other relays, which are held up over conductor 92, is established at the right-hand alternate contact of switching relay 16. This holding circuit for these relays may be traced from battery through contact 86 of switching relay 17, contacts of relays 10 and 7, right-hand alternate contact of switching relay 16, conductor 92, and windings of relays 21, 23, 26, 33, 37, 38 and 39 to ground. The opening of the left-hand normal contact of switching relay 16 opens the energizing circuit of line selection control relay 30, which thereupon releases its armatures. The closure of the left-hand alternate contact of switching relay 16 establishes a short circuit for the resistance 82, thereby permitting the operation of marginal relay 12 which disconnects the line selection control relay 30 from the ring talking strand, and connects the line conductors of line #3 to the tip and ring contacts of the jack of that line. The release of master relay 15 opens its right-hand alternate contact, thereby opening the energizing circuits of selection control relays 31 and 32, which thereupon release their armatures. The closure of the right-hand normal contact of master relay 15 establishes a short circuit for the resistance 85, whereupon marginal relay 8 of line #1 operates to disconnect the line selection control relay 18 from the ring talking conductor, and to connect the line conductors of line #1 to the tip and ring contacts of the jack of that line. Line #1 is now balanced by basic network 104 and line #3 by basic network 205, and the potentiometers 101 and 201 are set so that the two upper sections thereof are effective. The two lines #1 and #3 being connected together by the cord circuit A and its repeaters 100 and 200, are in condition for conversation between the stations joined thereby.

It will be apparent that the selection of the networks and the adjustment of the potentiometers to obtain the proper gain of the repeaters, take place before the two lines are connected together, thereby avoiding disagreeable clicks over the lines.

If connection is to be established between line #2 and line #4, the plugs 5 and 6 of the cord circuit A are inserted into jacks J_2 and J_4 of the respective lines. The connection of the plug 5 with the jack J_2 causes the operation of relays 7 and 56, while the insertion of the plug 6 into the jack J_4 causes the operation of relays 10 and 59. The operating circuit for relays 7 and 56 is from battery through the right-hand normal contact of master relay 15, the windings of relays 7 and 9 in parallel, sleeve contacts of the plug 5 and the jack J_2, resistance 73 and the winding of the marginal relay 56 to ground, and that for relays 10 and 59 is from battery, through resistance 82, windings of relays 10 and 11 in parallel, sleeve contacts of the plug 6 and the jack J_4, normal contact of relay 120, and windings of relays 59 and 57 to ground. Relay 57 is marginal and does not operate when resistance 82 is in circuit therewith. Relay 11 is also marginal and does not operate when connected in circuit with relays 59 and 57. The operation of relays 7 and 10, if the apparatus of no other cord circuit is at this time selecting, causes the operation of master relay 15 in the manner previously described. Relay 15 in opening its right-hand normal contact, removes the short circuit of the resistance 85, thereby including this resistance in circuit with relays 7, 9 and 56, whereupon marginal relay 56 releases its armatures, closing an operating circuit for line selection control relay 60.

Line selection control relay 60 of line #2 thereupon operates over a circuit from battery, through the contacts of master relays of other cord circuits, right-hand alternate contact of master relay 15, contact 87 thereof, contact 88 of switching relay 17, ring contacts of the plug 5 and the jack J_2, lower normal contact of relay 56 and the winding of relay 60 to ground. Selection-control relays 19 and 20 are likewise operated upon the energization of master relay 15, their operating circuit being that previously traced in connection with the establishment of connection between lines #1 and #3.

The operation of line selection control relay 60 and selection-control relay 19 causes the operation of relays 22, 62 and 70. Relays 22 and 62 operate over a circuit from battery, over conductor 92, winding of relay 22, a contact of selection-control relay 19, conductor 121, a normal contact and winding and another normal contact of relay 62, conductor B and a contact of line selection control relay 60 to ground. Relay 62 in operating completes a locking circuit for itself from battery, over conductor 92, alternate contact of relay 22, resistance 24, an alternate contact and winding and another alternate contact of relay 62, and the winding of relay 39 to ground. Relay 39 in operating causes the operation of potentiometer-control relay 45 which alters the setting of the potentiometers. Relay 70 operates over a circuit from battery, over conductor 92, winding of relay 22, a contact of selection-control relay 19, left-hand normal contact, winding and right-hand normal contact of relay 70, conductor 74 and a contact of line selection control relay 60 to ground. Relay 70 in operating completes a locking circuit for itself from battery supplied over conductor 92, through the alternate contact of relay 22, resistance 24 and left-hand alternate contact of relay 70, winding and right-hand alternate contact thereof to ground. Relay 70 in operating, causes the operation of relays 71 and 72 over a circuit from battery through the windings of these relays and a right-hand alternate contact of relay 70 to ground. The operation of relay 72 opens up contacts of conductors 134 and 135, and the operation of relay 71 connects the phantom balancing set 102 in circuit with these conductors for balancing the phantom repeating coil 160 connected in line #2.

The operation of line selection control relay 60 and selection control relay 20 causes the operation of relays 63 and 64. Relay 63 operates over a circuit from battery supplied over the conductor 92, through the winding of relay 22, middle contact of selection-control relay 20, lower normal contact, winding and upper normal contact of relay 63, conductor 75 and a contact of line selection control relay 60 to ground. Relay 63 in operating completes a locking circuit for itself from battery supplied over conductor 92, through alternate contact of relay 22, resistance 24, an alternate contact and winding and another alternate contact of relay 63 to ground. The closure of the uppermost contacts of relay 63 connects the basic network 105 with conductors 134 and 135. The operating circuit for relay 64 may be traced from battery supplied over conductor 92, through the winding of relay 22, right-hand contact of selection-control relay 20, left-hand normal contact, winding and right-hand normal contact of relay 64, conductor 76 and a contact of line selection control relay 60 to ground. Relay 64, in operating, completes a locking circuit for itself from battery supplied over conductor 92, through the alternate contact of relay 22, resistance 24, left-hand alternate contact, winding and right-hand alternate contact of relay 64 to ground. The operation of relay 64 causes the operation of relays 65 and 66 over a circuit from battery through the windings of these relays and a right-hand alternate contact of relay 64 to ground. The operation of relay 66 opens up contacts in conductors 134 and 135 and the operation of relay 65 connects building-out section 106 with these conductors. The basic network 105, building-out section 106 and the phantom balancing set 102 are now connected with the repeater 100 for balancing line #2 and the phantoming apparatus connected thereto. When relays 63, 64 and 70 have been energized and locked up, the circuit of relay 22 is opened, whereupon this relay releases its armature, completing a circuit for relay 26. The resulting operation of relay 26 causes the operation of slow-operating switching relay 17.

The operation of relay 17 through the opening of its contact 88 and right-hand normal contact, causes the release of line selection control relay 60 and selection control relays 19 and 20. The release of relay 60 removes a short circuit of marginal relay 56, thereby conditioning this relay for operation upon the subsequent release of master relay 15. The operation of switching relay 17 also causes the operation of line selection control relay 61 over a circuit from battery through contact 94 of relay 17, left-hand normal contact of relay 16, ring contacts of the plug 6 and the jack J_4, a normal contact of marginal relay 57 and winding of relay 61 to ground. Relays 61 and 59 being operated, relay 58 operates and locks up independent of the contact of relay 61. The operation of switching relay 17 also causes the operation of selection-control relays 31 and 32 over a circuit from battery through the right-hand alternate contact of

master relay 15, right-hand alternate contact of switching relay 17, conductor 93 and the windings of selection-control relays 31 and 32 in parallel, to ground.

The operation of line selection control relay 61 and selection-control relay 32 causes the operation of relays 34 and 77 over a circuit from battery supplied over conductor 92, through the winding of relay 34, conductor 89, right-hand contact of relay 32, lower normal contact, winding and upper normal contact of relay 77, conductor 78 and a contact of line selection control relay 61 to ground. Relay 77 in operating completes a locking circuit for itself from battery supplied over conductor 92, through the alternate contact of relay 34, resistance 146, an alternate contact winding and another alternate contact of relay 77 to ground. The closure of the uppermost contacts of relay 77 connects the basic network 204 with the conductors 156 and 157. The operation of line selection control relay 61 and selection control relay 32 also causes the operation of relay 36 over a circuit from battery supplied over conductor 92, through the winding of relay 34, conductor 89, left-hand contact of relay 32, right-hand normal contact, winding and left-hand normal contact of relay 36, conductor 79 and a contact of relay 61 to ground. Relay 36 in operating completes a locking circuit for itself over a circuit from battery supplied over conductor 92, through the alternate contact of relay 34, resistance 146, right-hand alternate contact, winding and left-hand alternate contact of relay 36 to ground. The closure of a left-hand alternate contact of relay 36 causes the operation of relays 49 and 50, the former opening up contacts in conductors 156 and 157 and the latter connecting the phantom-balancing set 202 with these conductors for balancing the phantom coil 123 connected in the line #4.

The operation of line selection control relay 61 and selection control relay 31 causes the operation of relays 35 and 67 to control the connection of the composite balancing set 203 and the building-out section 206 with conductors 156 and 157 for assisting in balancing the line #4. The operating circuit for relay 35 may be traced from battery supplied over conductor 92, through the winding of relay 34, a contact of relay 31, right-hand normal contact, winding and left-hand normal contact of relay 35, conductor 29 and a contact of relay 61 to ground. Relay 35 immediately completes a locking circuit for itself from battery supplied over conductor 92, through the alternate contact of relay 34, resistance 146, right-hand alternate contact, winding and left-hand alternate contact of relay 35 to ground. The closure of a left-hand alternate contact of relay 35 causes the operation of relays 47 and 48, the former opening up conductors 156 and 157, and the latter connecting building-out section 206 with these conductors. The operating circuit for relay 67 may be traced from battery supplied over conductor 92, through the winding of relay 34, a contact of relay 31, conductor 122, right-hand normal contact, winding and left-hand normal contact of relay 67, conductor 28 and a contact of relay 61 to ground. Relay 67, in operating, completes a locking circuit for itself which may be traced from battery supplied over conductor 92 through the alternate contact of relay 34, resistance 146, right-hand alternate contact, winding and left-hand alternate contact of relay 67 to ground. The closure of a left-hand alternate contact of relay 67 causes the operation of relays 68 and 69 over a circuit from battery through the contact of relay 11, conductor 27, windings of relays 68 and 69 and a left-hand alternate contact of relay 67 to ground. The operation of relay 68 opens up the conductors 156 and 157, and the operation of relay 69 connects composite balancing set 203 with these conductors. Relays 77, 36, 67 and 35 are now locked up, whereupon the energizing circuit of relay 34 is opened. The resulting release of this relay 34 closes an operating circuit for relay 38 which may be traced from battery supplied over conductor 92, through the normal contact of relay 34, winding of relay 38 and resistance 147, resistance 146 and the windings of the four relays 35, 36, 67 and 77 in parallel to ground.

Relay 38, in operating, causes the operation of switching relay 16 over a circuit from battery supplied over conductor 92, through the contact of relay 38, conductor 96 and the winding of switching relay 16 to ground. The closure of the right-hand alternate contact of relay 16 supplies battery to conductor 92, through the contacts of switching relay 17 and relays 7 and 10, so that upon the opening of the right-hand normal contact of relay 16 and the resulting release of relay 15, relays 26, 35, 38, 63, 64, 67, 70 and 77 will be held up over conductor 92. The opening of the left-hand normal contact of relay 16 causes the release of line selection control relay 61, and the closure of the left-hand alternate contact of this relay 16 establishes a short circuit for the resistance 82, whereupon marginal relay 57 of line #4 operates. This relay 57 in operating opens its normal contact, disconnecting the line selection control relay 61 from the line #4; closes its upper and middle alternate contacts, connecting the line wires of line #4 with the tip and ring contacts of jack J_4; and closes its lower alternate contact, causing the operation of marginal relay 120 over a circuit from battery through contact 94 of switch-

ing relay 17, left-hand alternate contact of switching relay 16, windings of relays 10 and 11 in parallel, sleeve contacts of the plug 6 and the jack J_4, winding of relay 120, left-hand contact of relay 58 and the lower alternate contact of relay 57 to ground. The operation of relay 120 closes its lower alternate contact before the normal contact thereof is opened, whereby relays 59 and 57 are maintained energized when their original energizing circuit is opened. Master relay 15, in releasing upon the energization of the switching relay 16, closes its right-hand normal contact, thereby establishing a short circuit for the resistance 85, whereupon the marginal relay 56 is operated to disconnect line selection control relay 60 from the line and to extend line #2 with the tip and ring contacts of the jack J_2. Lines 2 and 4 are now connected for conversation with basic network 105, building-out section 106 and the phantom balancing set 102 connected with the repeater 100 for balancing line #2, and the phantom coil 160 connected therewith and with basic network 204, building-out section 206, phantom balancing set 202 and composite balancing set 203 connected with the repeater 200 for balancing the line #4 and the phantom coil 123 and composite set (apparatus) 124 connected therewith. The settings of the potentiometers 101 and 201 are such that the two upper sections thereof are effective for controlling the inputs of the respective amplifiers.

If while lines 2 and 4 are connected for conversation, the composite set 124 is disconnected from line #4, the organization of apparatus and circuits is such that the composite balancing set 203 is immediately and automatically removed from the circuit. The disconnection of the composite set is brought about by connecting a plug 125 in each of the jacks 126 and 127, whereupon relays 128 and 129 operate over a circuit from battery through the winding of relay 128, alternate contact of jack 127, alternate contact of jack 126 and the winding of relay 129 to ground. The operation of these two relays disconnects the composite set 124 from line #4, and reestablishes the line through the alternate contacts of these relays. Relay 128 also closes its lower alternate contact, thereby including resistance 130 in parallel with the winding of relay 120, thereby reducing the resistance in circuit with the control relay 11 whereupon this relay operates to open the energizing circuits of relays 68 and 69. The release of relay 69 disconnects the composite balancing set 203 from the conductors 156 and 157, and the release of relay 68 reestablishes the continuity of conductors 156 and 157.

In the earlier part of the description of the system shown in the drawings, it has been stated that for convenience only a limited number of basic networks, building-out sections, composite balancing sets and phantom balancing sets were shown, and that in practice the number of these balancing arrangements would very likely be greatly increased, depending, of course, upon the number and different types of lines entering the central office. If other balancing arrangements similar to those shown in the drawing are to be provided, then, for each such balancing arrangement, there must be provided a relay, similar to relay 23, for each basic network, or relays similar to 70, 71 and 72 for each balancing-out section, composite balancing set and phantom balancing set. Each control relay similar to 23 and 70, so provided, would be controlled in the same manner, namely, from a contact on a connecting circuit selection control relay similar to 19, and from a contact on a line selection control relay similar to 18.

In order that a complete understanding may be had of the manner in which the potentiometer-control relays 44, 45 and 46 adjust the potentiometers 101 and 201 to secure a gain suitable for the lines which are connected together by means of the cord circuit A, the following brief description of the operation of the intermediate control relays 21, 33, 39, 40, 41, 42 and 62 will be given. These intermediate control relays are, of course, under the control of the cord and line selection control relays.

If two lines of the type represented by line #1 are connected together by means of the cord circuit A, then intermediate control relays 21 and 40 operate and lock up, causing the energization of potentiometer-control relay 45 over a circuit from battery through the winding of this relay, extreme left-hand contact of relay 40 and extreme right-hand contact of relay 21 to ground. The two upper sections of the potentiometers are therefore effective for controlling the gain of the repeaters. Upon the connection of the cord circuit A with two lines, of the type represented by line #2, then intermediate control relays 41, 62 and 39 are operated. Relay 39 causes the operation of potentiometer-control relay 45, and the operation of relays 62 and 41 causes the operation of potentiometer-control relay 46 over a circuit from battery through the winding of this relay 46, extreme right-hand contact of relay 62, and extreme left-hand contact of relay 41 to ground. With potentiometer control relays 45 and 46 operated, the potentiometers are adjusted so that the three upper sections thereof are effective for controlling the gain of the repeaters. If two lines of the type represented by line #3 are connected together by means of the cord circuit A, then intermediate control relays 33, 39 and 42 are operated, relay 39 causing the operation of potentiometer-control relay 45,

and the operation of relays 33 and 42 causing the operation of potentiometer control relay 44 over a circuit from battery through the winding of this relay 44 and the extreme right-hand contacts of relays 33 and 42 to ground. When potentiometer control relay 44 is operated, all of the sections of the potentiometer are effective for controlling the gain of the repeaters. If two lines of the type represented by line #4 are connected together, none of the intermediate control or potentiometer-control relays are operated, whereby the setting of the potentiometers remains normal with the upper of the four sections thereof effective for controlling the gain of the repeaters.

If line #1 is connected with line #2 through the cooperation of the plug 5 with line #1 and the plug 6 with line #2, then intermediate control relays 21, 39 and 41 are operated, and if by the cooperation of the plug 6 with line #1 and the plug 5 with line #2, intermediate control relays 42, 62 and 39 are operated. In either case, potentiometer control relay 45 is operated, rendering the two upper sections of the potentiometers effective for controlling the gain of the repeaters. When line #1 is connected with line #3 through the cooperation of the plug 5 with line #1 and the plug 6 with line #3, intermediate control relays 21, 33 and 39 are operated, and when through the cooperation of the plug 6 with line #1 and the plug 5 with line #3, intermediate control relays 40, 42 and 39 are operated. In either case, potentiometer-control relay 45 is operated. With line #1 connected with line #4 through the cooperation of the plug 5 with line #1 and the plug 6 with line #4, intermediate control relay 21 is operated, and if through the cooperation of the plug 6 with line 1 and the plug 5 with line #4, intermediate control relay 40 is operated. In either case, none of the potentiometer-control relays are operated, whereby the setting of the potentiometers is not altered.

Should line #2 be connected with line #3 through the cooperation of the plug 5 with the former and the plug 6 with the latter, intermediate control relays 62, 33 and 39 are operated, causing the operation of potentiometer-control relays 45 and 46, and if through the cooperation of the plug 6 with line #2 and the plug 5 with line #3, intermediate control relays 41, 42 and 39 are operated to cause the operation of the same potentiometer-control relays. By connecting together lines #2 and #4 through the cooperation of the plug 5 with the former and the plug 6 with the latter, intermediate control relays 62 and 39 are operated, which cause the operation of potentiometer control relay 45, while through the cooperation of the plug 6 with line #2 and the plug 5 with line #4, intermediate control relays 41 and 39 operate to cause the operation of the same potentiometer-control relay.

The connection of lines #3 and #4 through the cooperation of the plug 5 with line #3 and the plug 6 with line #4, causes the operation of intermediate control relays 42 and 39, and through the cooperation of the plug 6 with line #3 and the plug 5 with line #4, causes intermediate control relays 33 and 39 to operate. In either case, potentiometer-control relay 45 is operated.

What is claimed is:

1. In a telephone repeater system, in combination, a telephone line, an artificial balancing line, a repeater, a connecting circuit for associating the repeater with the telephone line, a control relay normally associated with the telephone line, a control relay associated with the connecting circuit and cooperating with the line control relay upon the association of the connecting circuit with the telephone line for controlling the connection of the artificial line with the repeater for balancing the telephone line, and means thereupon rendered effective for disconnecting the line control relay from the telephone line.

2. In a telephone repeater system, in combination, a telephone line, an artificial balancing line, a repeater, a connecting circuit for associating the repeater with the telephone line, a control relay normally associated with the telephone line, a control relay associated with the connecting circuit and cooperating with the line control relay upon the association of the connecting circuit with the telephone line for controlling the connection of the artificial line with the repeater for balancing the telephone line, and a relay thereupon rendered effective for disconnecting the line control relay from the telephone line.

3. In a telephone repeater system, in combination, a telephone line, an artificial balancing line, a repeater, a connecting circuit for associating the repeater with the telephone line, a control relay normally associated with the telephone line and operating over a circuit including a portion of the talking circuit of the associated line and connecting circuit, a control relay associated with the connecting circuit and cooperating with the line control relay to control the association of the artificial balancing line with the repeater for balancing the telephone line, and a relay operating after the association of the artificial balancing line with the repeater for disconnecting the line control relay from the telephone line.

4. In a telephone repeater system, in combination, a telephone line, an artificial balancing line, a repeater, means for associating the repeater with the telephone line, a control relay normally associated with the telephone line, a control relay associated with

the connecting means, a relay operating when both control relays are energized to associate the artificial balancing line with the repeater for balancing the telephone line, and a relay thereafter responsive for disconnecting the line control relay from the telephone line.

5. In a telephone repeater system, in combination, a plurality of telephone lines, a plurality of artificial balancing lines, a repeater, means for connecting the repeater with one of the telephone lines, a selection-control relay normally connected with the engaged telephone line, a selection-control relay associated with the connecting means and cooperating with the line selection control relay to select and connect with the repeater one of the artificial balancing lines, and a relay rendered effective upon the connection of the artificial line with the repeater for disconnecting the line selection control relay from the telephone line.

6. In a telephone repeater system, in combination, a plurality of telephone lines, a plurality of artificial balancing lines, a repeater, means for connecting the repeater with one of the telephone lines, a selection-control relay operating over a circuit including a portion of the talking circuit of the telephone line and the connecting means, a selection-control relay associated with the connecting means and cooperating with the operated line selection control relay to select and connect with the repeater one of the artificial balancing lines, and means rendered effective upon the connection of the artificial line with the repeater for disabling the operating circuit of the line selection control relay.

7. In a telephone repeater system, in combination, two telephone lines, a plurality of balancing lines, two repeaters for interconnecting said telephone lines, means for associating the repeaters with the respective telephone lines, means for selecting and associating one of the balancing lines with each repeater for balancing the respective associated line, means responsive to the association of the repeaters with the telephone lines for rendering the selecting means effective for selecting one balancing line, and means operative after such selection for rendering the selecting means effective for selecting another balancing line.

8. In a telephone repeater system, in combination, two telephone lines, a plurality of balancing lines, two repeaters for interconnecting said telephone lines, means for associating the repeaters with the respective telephone lines, means for selecting and associating a balancing line with each repeater for balancing the respective associated lines, a switching relay operating upon the association of the repeaters with both lines for causing the selecting means to select and associate a balancing line with one repeater, and a switching relay rendered effective upon the selection of the one balancing line for causing the selecting means to select and connect with the other repeater another balancing line.

9. In a telephone repeater system, in combination, a telephone line, auxiliary apparatus associated therewith, a repeater, an artificial balancing line for balancing the telephone line, an auxiliary balancing set for balancing the auxiliary apparatus, means for associating the artificial line and auxiliary set with the repeater for balancing the telephone line and associated auxiliary apparatus, means for disconnecting the auxiliary apparatus from the telephone line, and marginal means responsive to such disconnection to disconnect the auxiliary balancing set from the repeater.

10. In a telephone repeater system, in combination, a telephone line, auxiliary apparatus associated therewith, a repeater, an artificial balancing line for balancing the telephone line, an auxiliary balancing set for balancing the auxiliary apparatus, means for associating the artificial line and auxiliary set with the repeater for balancing the telephone line and associated auxiliary apparatus, means for disconnecting the auxiliary apparatus from the telephone line, a marginal relay operating upon such disconnection, and means responsive to the operation of the relay for disconnecting the auxiliary balancing set from the repeater.

11. In a telephone repeater system, in combination, a telephone line, auxiliary apparatus associated therewith, a repeater, an artificial balancing line for balancing the telephone line, an auxiliary balancing set for balancing the auxiliary apparatus, means for associating the artificial line and auxiliary set with the repeater for balancing the telephone line and associated auxiliary apparatus, means for disconnecting the auxiliary apparatus from the telephone line, a marginal relay controlling the disconnection of the auxiliary balancing set from the repeater, and an operating circuit therefor whose resistance is lowered by the disconnection of the auxiliary apparatus from the telephone line, whereby the marginal relay is operated.

12. In a telephone repeater system, in combination, a plurality of telphone lines, a repeater, a plurality of balancing lines, switching means for associating one of the balancing lines with the repeater, and means responsive to said association for subsequently connecting the repeater and balancing line with a telephone line whereby said repeater is made responsive to currents in said last-mentioned telephone line.

13. In a telephone repeater system, in combination, a plurality of telephone lines, terminal apparatus for each telephone line normally disconnected therefrom, a repeater, means for connecting the repeater with the terminal apparatus of one line, a plurality of artificial balancing lines, switching means for associating one of the balancing lines with the repeater, and means for subsequently connecting the associated balancing line, repeater and terminal apparatus with the telephone line whereby said repeater is made responsive to currents in said last-mentioned telephone line.

14. In a telephone repeater system, in combination, two telephone lines, a plurality of balancing lines, a connecting circuit for associating the repeaters with the telephone lines, automatic selecting means for selecting and associating balancing lines with the respective repeaters for balancing the respective telephone lines, and means for thereafter connecting the telephone lines together through the connecting circuit whereby intercommunication between said telephone lines may be established.

15. In a telephone repeater system, in combination, two telephone lines, a plurality of balancing lines, two repeaters, a connecting circuit for associating the repeaters with the telephone lines, a plurality of relays rendered effective upon the association of the repeaters with the telephone lines for selecting and associating balancing lines with the respective repeaters, and relays operating upon said selection and association for connecting the telephone lines together through the connecting circuit.

16. In a signaling system, a plurality of lines of different types, repeaters for interconnecting said lines, balancing networks for said lines, and a relay individual to each repeater, said relay operating, when the corresponding repeater is used for connecting lines, to first cause the selecting of a network suitable for balancing the line with which one end of the repeater is associated, and thereafter cause the selection of a network suitable to balance the line associated with the other end of the repeater, said relay also preventing the selection of networks by other repeaters while that repeater is selecting.

17. In a signaling system a plurality of lines of different types, repeaters for interconnecting said lines, balancing networks for said lines, and a relay individual to each repeater, said relay operating, when the corresponding repeater is used for connecting lines, to first cause the selection of a network suitable for balancing the line with which one end of the repeater is associated, and thereafter cause the selection of a network suitable to balance the line associated with the other end of the repeater, the circuits of said relays for the several repeaters being so arranged that when the relay of one repeater is energized during the process of network selection, the circuits of the relays of other repeaters will be held until the process of selection for that repeater is completed.

18. The method of selecting balancing lines for two signal transmission lines which are to be interconnected through a repeater circuit, which comprises associating said repeater circuit with said lines while still preventing intercommunication between said lines, selecting the proper balancing line for one of said transmission lines, selecting the proper balancing line for the other of said transmission lines after said first selection is completed, and subsequently connecting said lines through said repeater circuit for intercommunication purposes.

19. In a repeater system, two real lines, a plurality of artificial networks for said real lines, a repeater circuit for interconnecting said real lines, means for associating said repeater circuit with said real lines, and switching means responsive to said association for selecting an artificial network for one of said real lines and subsequently selecting an artificial network for the other of said real lines.

20. In a repeater system, two real lines, a plurality of artificial networks for said real lines, a repeater circuit for interconnecting said real lines, means for associating said repeater circuit with said real lines, switching means responsive to said association for selecting an artificial network for each of said real lines, and means comprising relays for controlling said selecting means to cause an artificial network for one of said real lines to be selected only after an artificial network has been selected for the other of said real lines.

21. In a repeater system, a signal transmission line, auxiliary apparatus normally associated therewith, an artificial line for balancing said signal transmission line, an auxiliary balancing set for balancing said auxiliary apparatus, switching means for disconnecting said auxiliary apparatus from said line and marginal means responsive to the disconnection of said auxiliary apparatus for disconnecting said auxiliary balancing set.

22. In a repeater system, a signal transmission line, auxiliary apparatus associated therewith, an artificial line for balancing said signal transmission line, an auxiliary balancing set for balancing said auxiliary apparatus, switching means for rendering said auxiliary apparatus ineffective, and marginal means responsive to the operation of said switching means for rendering said balancing set ineffective.

23. The method of interconnecting a signal transmission line, a balancing line there-

for and a repeater, which comprises connecting said balancing line to said repeater and subsequently connecting in response to said first connection said repeater and balancing line to said telephone line to cause said repeater to be responsive to currents in said transmission line.

24. The method of establishing communication between two signal transmission lines through a repeater circuit, which comprises associating with said repeater a balancing line for each of said transmission lines, and subsequently in response to said association connecting said repeater and said balancing lines to said transmission lines whereby intercommunication therebetween may be established.

25. In a telephone repeater system, a plurality of telephone lines, a repeater, a plurality of balancing lines, switching means for associating one of said balancing lines with said repeater, and means comprising a relay responsive to the association of said balancing line with said repeater for subsequently connecting said repeater and balancing line with a telephone line.

26. In a signaling system, a plurality of lines of different types adapted to be interconnected by any one of a plurality of two-way repeaters, and a master relay individual to each repeater, each of said relays operating when the corresponding repeater is used for connecting lines to first cause the selecting of a network suitable for balancing the line with which one end of the repeater is associated, and thereafter cause the selection of a network suitable to balance the line associated with the other end of the repeater and means for preventing the simultaneous operation of two of said master relays, each of which is normally adapted to select a common balancing network.

27. In a signaling system a plurality of lines of different types, repeaters for interconnecting said lines, balancing networks for said lines, and switching means associated with each repeater and responsive to the association of its repeater with two of said lines for causing, first, the selection of a network suitable for balancing the line with which one end of the repeater is associated and thereafter causing the selection of a network suitable to balance the line associated with the other end of the repeater.

28. In a signaling system, a plurality of lines of different types, repeaters for interconnecting said lines, balancing networks for said lines, and a relay individual to each repeater operative when the corresponding repeater is used for interconnecting lines to cause the selection of balancing networks for the lines, and to prevent the selection of networks by other repeaters while that repeater is selecting, movable contacts for said relays, a source of current, said relays when deenergized having movable contacts serially connected with said source and having other movable contacts serially connected to ground.

29. In a signaling system, a plurality of lines of different types, repeaters for interconnecting said lines, balancing networks for said lines, and a relay individual to each repeater operative when the corresponding repeater is used for interconnecting lines to cause the selection of balancing networks for the lines and to prevent the selection of networks by other repeaters while that repeater is selecting, movable contacts and electrical windings for said relays, each of said relays having a plurality of movable contacts serially connected with contacts of other of said relays when the electrical windings of said relays are in the same electrical condition.

30. The method of balancing a plurality of signal transmission lines having different impedances in which a common basic network and a plurality of building-out sections are employed, which method comprises connecting in circuit with one of said transmission lines which is to be balanced, a basic network, disconnecting said network and subsequently connecting in circuit with another transmission line which is to be balanced said basic network and one of said building-out sections.

31. In a signaling system, a plurality of real lines having different impedances to be balanced, a basic network and a plurality of building-out sections for balancing said lines, switching means for connecting said basic network in circuit with a line to be balanced, and switching means for subsequently balancing another of said lines by connecting in circuit therewith said basic network and one of said building-out sections.

32. In a signaling system, a plurality of real lines to be balanced, said lines having widely different impedances, a common basic network for said lines, and switching means for connecting said basic network at times to one of said lines and at other times to another of said lines while maintaining the same degree of balance for both of said lines.

33. The combination of a signal transmission line, a repeater and an artificial line therefor, said artificial line having an impedance less than the impedance of said transmission line and means responsive to the association of said repeater with said transmision line to change said artificial line to a value simulating the impedance of said transmission line.

34. In a signaling system, a plurality of lines, repeaters for interconnecting said lines, balancing networks for said lines, a master relay individual to each repeater, means un-

der the control of said master relay for selecting a balancing network for one of said lines, means for selecting a balancing network for a second of said lines whereby intercommunication is established between said last two lines, and means responsive to said first selection for transferring the control of said master relay to said second means whereby the second balancing network is selected.

In witness whereof I hereunto subscribe my name this 23rd day of December, A. D. 1918.

ROY D. CONWAY.