Feb. 13, 1923. 1,444,830

C. S. DEMAREST

TRANSMISSION CONTROLLING APPARATUS

Filed Aug. 9, 1919 3 sheets-sheet 1

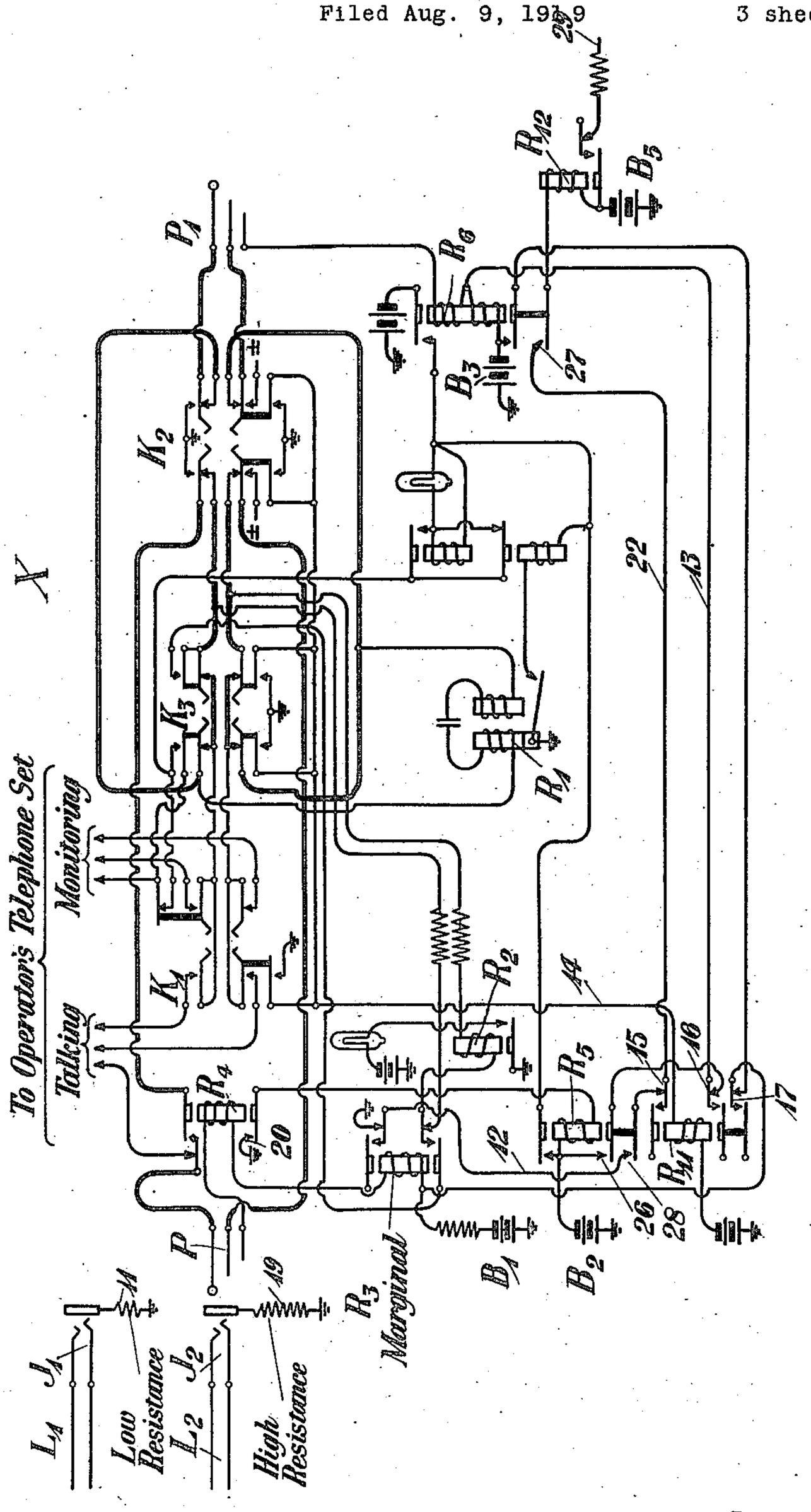

Fig. 1

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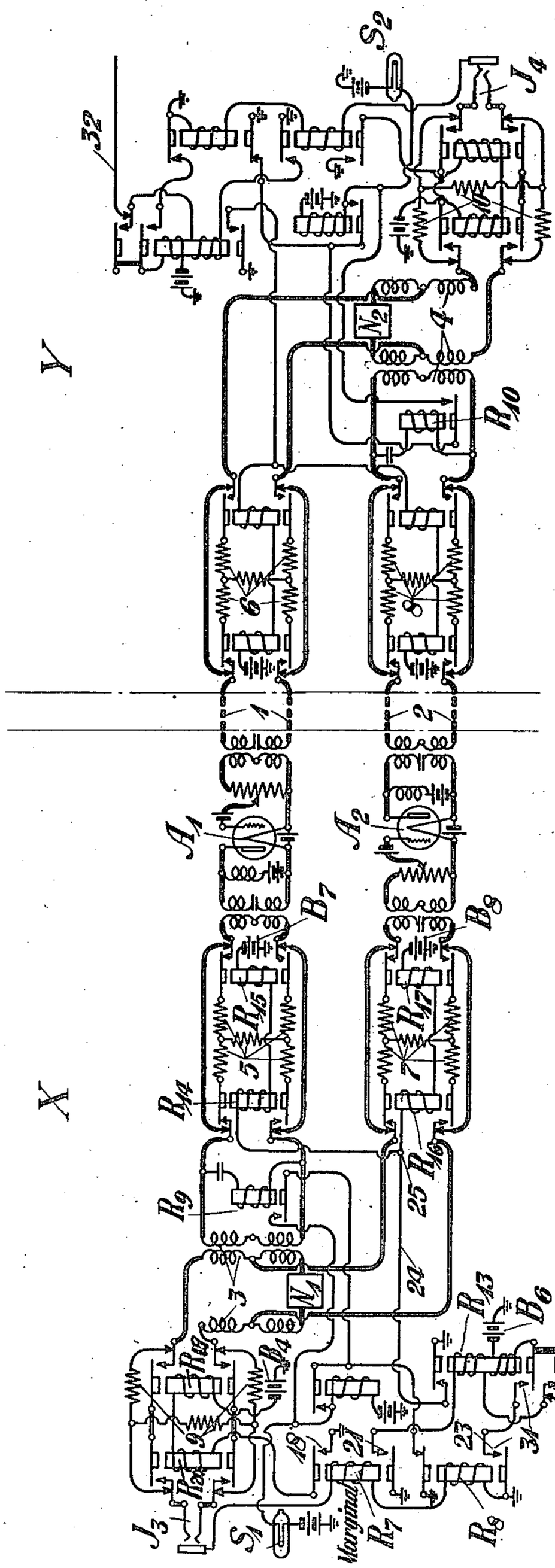

Fig. 2

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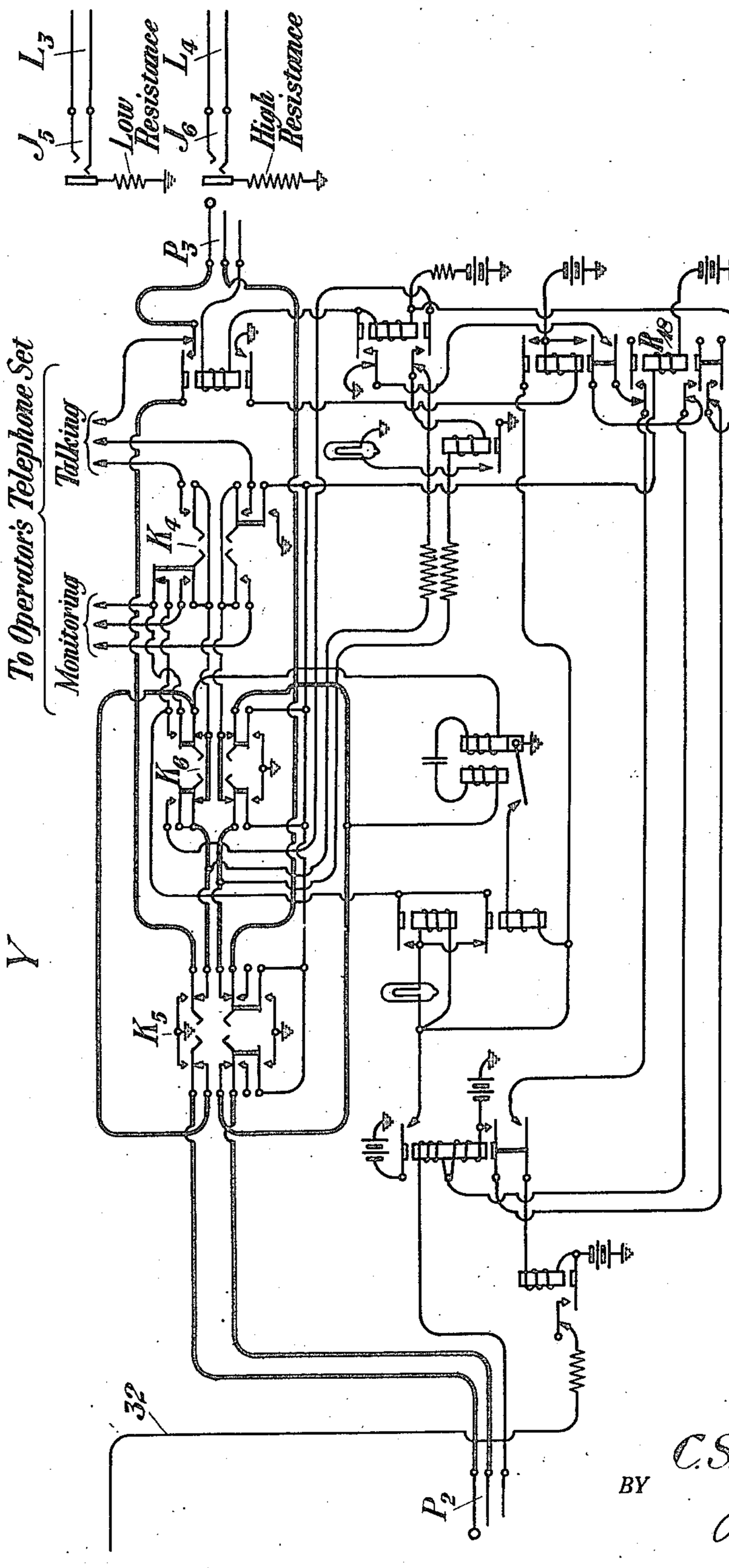

Fig. 3

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Patented Feb. 13, 1923. 1,444,830

UNITED STATES PATENT OFFICE.

CHARLES S. DEMAREST, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TRANSMISSION-CONTROLLING APPARATUS.

Application filed August 9, 1919. Serial No. 316,416.

To all whom it may concern:

Be it known that I, CHARLES S. DEMAREST, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Transmission-Controlling Apparatus, of which the following is a specification.

This invention relates to transmission controlling apparatus and more particularly to means for controlling the operation of four-wire repeater circuits.

In the operation of four-wire repeater circuits having a repeater element in each of its two sides, it is well known that the repeater elements may be adjusted so as to produce varying degrees of amplification of the input current or voltage wave. Such repeaters may be adjusted to produce an amplification of such magnitude that the output current at one end of the four-wire circuit is equal to the input current at the other end of the said circuit, or they may be adjusted so that the output current at one end of the circuit is greater than the input at the other end of the circuit, in which case the circuit is said to have a transmission equivalent better than zero between terminals. The latter condition is sometimes desirable when it is intended to connect two-wire telephone trunk circuits with each end of the four-wire repeater circuit. By doing this part of the losses due to the trunk circuits may be overcome.

In the operation of four-wire repeater circuits having transmission equivalent better than zero between terminals, a difficulty known as "singing" arises when the line circuit connected with the four-wire circuit is not balanced by the balancing network associated with the four-wire circuit. Such an unbalanced condition may arise, for example, when the operator at each end of the four-wire circuit has inserted a plug of a toll cord in the terminal jack of the four-wire circuit and has operated the listening key of the cord circuit preparatory to completing a through connection. When such a situation exists, if an electrical disturbance reaches the repeater circuit over the cord circuit connected thereto, which does not balance the network, part of the energy flows around a circuit known as the "singing path" comprising the two repeater elements and the two triple-winding transformers, which effect the relation between the two sides of the four-wire circuit. If the repeater elements are adjusted so that the gain atained thereby is greater than the loss due to the circuits, such disturbance entering the "singing path" will increase in magnitude and change in frequency until a limit, determined by the energy handling capacity of the elements, is reached, thereby resulting in what is commonly known as "singing" of the repeaters.

This is objectionable because it impairs the transmission of the repeater circuit, and, therefore makes supervision by the operators over this circuit more difficult. This invention provides means to prevent the "singing" of the repeater during the period preceding the establishment of the through-line connection, and during such times thereafter when any key of a cord circuit, other than the monitoring key has been operated.

Furthermore, when a four-wire circuit of the type heretofore referred to, which is adapted to have a transmission equivalent better than zero between its terminals, is connected at each end with another trunk line, the transmission equivalent of the complete circuit will depend largely upon the transmission equivalents of the lines connected at each end. Thus, if the repeaters of the four-wire circuit are adjusted so as to give a gain such that when the four-wire circuit connects the two longest trunk circuits, the transmission over the through-line connection will be satisfactory, it is evident that when the same four-wire circuit connects together two shorter trunk circuits having better transmission equivalents than the trunk circuits previously mentioned a better grade of transmission will be obtained. It is desirable that the transmission over various through-line circuits shall be substantially uniform and it is one of the objects of this invention to provide means to regulate the transmission gain so as to equalize the equivalents of all classes of telephone connections.

Further objects of this invention will appear from the following description of the invention when read in connection with the attached drawing embraced in Figures 1, 2 and 3, which, when Figs. 2 and 3 are respectively placed to the right of the preceding figure, represents a circuit diagram of one embodiment of the invention.

Fig. 1 shows the jacks J_1 and J_2 constitut-

ing the terminals of two telephone lines L_1 and L_2 which typify two groups of two-wire trunk lines with which the four-wire circuit is adapted to be connected by means of a toll cord circuit at office X.

Fig. 2 represents a four-wire transmission circuit terminating in one office in jack J_3 and in the other office in jack J_4 and having associated therewith repeater elements A_1 and A_2, which are connected with the two-wire branches 1 and 2 respectively.

Fig. 3 which is similar to Fig. 1 represents a toll cord circuit at office Y for connecting the four-wire circuit with the trunk lines extending from that office.

In Fig. 1, L_1 and L_2 represent two telephone trunk lines which terminate at the office X in the jacks J_1 and J_2, respectively. L_1 represents a long trunk line over which supervision is maintained by alternating current, on account of its length. L_2 is typical of short-haul trunk lines over which supervision may be maintained by direct current. A toll cord circuit, located at the said office for the purpose of connecting the four-wire transmission circuit with either of the lines L_1 or L_2, terminates in plugs P and P_1, plug P being normally adapted to be inserted in jack J_1 or J_2, and plug P_1 being normally adapted to be inserted in jack J_3 of the four-wire circuit shown in Fig. 2 although plug P may be inserted in jack J_3 and plug P_1 in jack J_1. The toll cord has associated with it a key K_1, the right hand contacts of which are adapted to establish a monitoring connection between the operator's telephone set and the lines with which the cord circuit may be connected, and the left hand contacts of said key for the purpose of establishing a talking connection. Toward the right hand side of the cord circuit is a ringing key K_2 by means of which ringing current may be applied to lines connected with either end of the cord circuit. A splitting key K_3 is adapted to open the two sides of the cord circuit and thereby separate the circuits connected with each end of the cord circuit. This cord circuit is adapted for both alternating current and direct current supervision by means of relays R_1 and R_2, respectively. The other relays shown in connection with this cord circuit provide part of the means for the prevention of "singing" of the repeaters and for equalizing the transmission equivalents of the through-line connections, and will be more fully described later in connection with the description of the mode of operation of the transmission circuit.

Fig. 2 represents a four-wire telephone transmission circuit terminating at the office X in the jack J_3 and at the office Y in the jack J_4. This four-wire circuit is of the usual type, consisting of two two-wire branches designated 1 and 2, in which are located repeater elements A_1 and A_2, respectively. These two-wire branches are electrically associated with each other by means of triple winding coils 3 and 4. Associated with the said coils are networks N_1 and N_2, respectively, which are adapted to balance the lines that terminate in offices X and Y, respectively, with which said four-wire circuit may be connected. In the two-wire branch 1 are networks 5 and 6 and in branch 2 are networks 7 and 8, which are adapted to regulate the transmission equivalent of the four-wire transmission circuit. Connected with the two-wire terminals in which the four-wire circuit terminates at the offices X and Y are net works 9 and 10, respectively, which are designed to give sufficiently accurate balance to prevent "singing" of the repeater, and at the same time to permit satisfactory transmission between operators at the offices X and Y, which is necessary for proper supervision. The relays shown in this figure cooperate with those shown in Fig. 1 for the purpose of controlling the selection and the connection of the various networks with the circuit and their function will be more fully described hereafter in connection with the description of the mode of operation of this circuit.

Fig. 3 shows a telephone cord circuit similar to that shown in Fig. 1. This cord circuit terminates in plugs P_2 and P_3, P_2 being normally adapted for connection with jack J_4 of the four-wire circuit, and plug P_3 being normally adapted for connection with jacks J_5 and J_6 of trunk lines L_3 and L_4 which extend from office Y. Lines L_3 and L_4 are of the same type as lines L_1 and L_2, respectively, shown in Fig. 1, and heretofore referred to. However, plug P_2 may be inserted in jack J_5 of line L_3 and plug P_3 in jack J_4, since the cord circuit is adapted to function properly when so connected.

Let it be assumed that the operator at office X has received an incoming call over line L_1, and it is necessary, in order to complete the desired connection, to establish a circuit from line L_1, over the four-wire circuit to the office Y, and thence over trunk line L_3 to the local office in which the line of the desired party terminates. After the operator at X has obtained the requisite information by inserting plug P in jack J_1 and talking with the operator at the distant end of line L_1, the operator at office X inserts the plug P_1 in the jack J_3 of the four-wire transmission circuit. By the insertion of plug P in jack J_1 a circuit is established from battery B_1, winding of relays R_3 and R_4, sleeve contacts of plug P and jack J_1, resistance 11 to ground. Since resistance 11 is sufficiently low, relays R_3 and R_4 will

be operated. By the operation of the lower contact of relay R_3 the circuit of the direct current supervisory relay R_2 is opened thereby removing the bridged relay from the line. This is desirable since lines such as L_1 use only alternating current for supervisory signaling. By the operation of the upper contact of relay R_3 a ground is removed from conductor 12, the function of which will be shown later. By the closing of the upper contact of relay R_4 the tip side of the cord circuit is completely closed through; and by the closing of its lower contact 20 the winding of relay R_5 is grounded, closing a circuit from battery B_2, through the winding of relay R_5 to ground, thereby causing the operation of said relay.

By the insertion of plug P_1 in jack J_3, a circuit is established from battery B_3, winding of relay R_6, sleeve contacts of plug P_1 and jack J_3, windings of relays R_7 and R_8 to ground, thereby causing the operation of relays R_6 and R_8. Relay R_7 is marginal and under the conditions mentioned does not receive sufficient current to operate it. After plug P_1 has been inserted in jack J_3 the operator at X applies ringing current to the four-wire transmission circuit by the operation of key K_2 which causes the operation of relay R_{10} and in consequence thereof the lighting of the lamp S_2 which is associated with jack J_4. In response to this signal the operator at Y inserts plug P_2 of her cord circuit in jack J_4 and operates the talking key K_4 of her cord circuit so that she may converse with the calling operator. When the left hand contacts of key K_1 of the cord circuit at office X and the right hand contacts of key K_4 at Y are operated a ground is put upon the windings of relays R_{11}, and R_{18}, which causes the operation of the said relays and by the closing of their upper and lower contacts the circuits, which are normally closed through the contacts of said relay, are thereby opened.

Let us assume that in order to complete the desired connection the operator at Y has inserted plug P_3 in jack J_5 of line L_3 and that the operators at both offices have restored to their normal positions all the keys of both cord circuits so that the completed through-line circuit is adapted for the best talking conditions. When the key K_1 of the cord circuit at X has been restored to its normal position the ground is removed from relay R_{11}, thereby deenergizing this relay. Since relay R_5 is operated, a circuit is established from battery B_2, contact 26 of relay R_5, contact 16 of relay R_{11}, conductor 13, through part of the winding of relay R_6, sleeve contacts of plug P_1, and jack J_3, and windings of relays R_7 and R_8 to ground. Under this condition the marginal relay R_7 is operated. By the closing of contact 18 of relay R_7 a circuit is established from battery B_4, through the windings of relays R_{19} and R_{20} to ground, thereby causing the operation of the said relays and disconnecting the network 9 from the two-wire terminal of the four-wire circuit. In a similar manner the network 10 in the two-wire terminal of the four-wire circuit at office Y is disconnected from the said circuit. Since the networks 9 and 10, which have the same impedance as the lines, are normally connected into the two-wire terminals of the four-wire circuit they balance the repeater circuit and prevent the singing of the repeaters which otherwise would result from the unbalanced condition of the circuits connected with each end of the four-wire circuit. By the removal of these networks, which act as impedance bridges across the terminals of the four-wire circuit, the transmission over the entire through-line connection is improved thereby and the desired transmission equivalent of the said through-line connection is attained.

If it becomes necessary for an operator to talk over the circuit after the through-line connection has been established, it is desirable, in order to prevent "singing" of the repeaters, to reconnect networks 9 or 10 or both of them during the period in which such supervision is maintained. Thus, if the operator at office X, for example, desires to maintain such supervision she moves key K_1, to the talking position, thereby grounding conductor 14 and the winding of relay R_{11} which operates the said relay. By the opening of contact 16 of relay R_{11} battery B_2 is disconnected from the winding of relay R_6, thereby diminishing the amount of current passing through marginal relay R_7 and the other relays in the same circuit. Relay R_7 is thereby deenergized, opening contact 18 which results in the releasing of relays R_{19} and R_{20}. As the result network 9 is reconnected with the two-wire terminal at office X of the four-wire circuit. In a similar manner the network 10 may be reconnected with the two-wire terminal of the four-wire circuit at office Y if the operator at this office moves key K_4 of her cord circuit into its talking position in order to supervise the connection.

From the foregoing description it will be seen that this invention provides means for automatically disconnecting the impedance networks from the terminal coonductors of a four-wire telephone repeater circuit whenever the desired through-line connection has been completely established and all cord circuit keys, except the monitoring key, restored to their normal positions; and for automatically reconnecting said networks whenever any keys, other than the monitor-

ing key, have been operated, or whenever the cord circuit has been disconnected from the trunk line.

A further object of this invention is to equalize the transmission over various through-line connections. This is done in the following manner:

Let us assume that the operator at X has received a call over the line L_2 which has a lower transmission equivalent than lines of the group represented by L_1. The operator at X inserts plug P of the cord circuit in jack J_2 and by throwing the key K_1 to its talking position she learns from the operator at the distant end of the line L_2 that a telephone connection is required which necessitates the use of the four-wire circuit extending to the office Y, and also of the line L_4 extending from the latter office to a distant local office.

The operator at X inserts plug P_1 of her cord circuit in jack J_3 of the four-wire circuit, and by means of key K_2 she signals to the operator at Y, who responds by inserting plug P_2 in jack J_4 and then inserts plug P_3 in jack J_6 of line L_4. When the plug P was inserted in jack J_2 a circuit was established from battery B_1, windings of relays R_3, and R_4, sleeve contacts of plug P and jack J_2 and resistance 19 to ground. Relay R_4 will be operated thereby, but on account of the high value of the resistance element 19, the marginal relay R_3 will not be operated. In consequence of the non-operation of relay R_3, the direct current supervisory relay R_2 remains bridged across the line, which is necessary since L_2 is of that type of lines over which direct current is used for supervisory signalling. Relay R_5 will be operated through the closing of contact 20 of relay R_4, but in view of the fact that key K_1 is still in its talking position, relay R_{11} will be operated which, by the opening of its contacts 15 and 16, opens the circuits through the contacts of relay R_5, and by the opening of contact 17 opens the circuit from relay R_6 to relay R_7. When plug P_1 has been inserted in jack J_3 relays R_6 and R_8 will be operated but marginal relay R_7 will not be operated. After the operator at Y has established the desired through-line connection by inserting plug P_3 in jack J_6 of the line L_4 and the called subscriber has answered, the operators at both offices restore all the keys to their normal positions, thereby removing the ground from relay R_{11} at office X and from the corresponding relay R_{18} of the cord circuit at office Y and the said relays will be deenergized. Through the deenergization of relay R_{11} at office X its contacts 15, 16 and 17 are closed. Since relay R_5 has already been operated, a circuit will be established from battery B_2, contact 26 of relay R_5, contact 16 of relay R_{11}, conductor 13, through part of the winding of relay R_6, sleeve contacts of plug P_1 and jack J_3 and windings of relays R_7 and R_8 to ground. Relay R_7 now receives sufficient current to effect its operation, thereby closing its upper contact 18 which disconnects the network 9 from the four-wire circuit. Since relay R_6 has been operated by the insertion of plug P_1 in jack J_3, a circuit will be established from battery B_5, winding of relay R_{12}, contact 27 of relay R_6 conductor 22, contact 15 of relay R_{11}, contact 28 of relay R_5, and contact of relay R_3 to ground. It will be recalled that relay R_3 is not operated owing to the high value of resistance element 19. Relay R_{12} is operated and closes momentarily a circuit from battery B_5, contact of relay R_{12}, conductor 29, contact 30 of relay R_{13}, through the upper winding of relay R_{13} and contact 21 of relay R_7 to ground, thereby causing the operation of relay R_{13} which is locked up by current through a circuit from battery B_6, lower winding of relay R_{13}, contact 31 of said relay and contact 23 of relay R_8 to ground. Through the closing of the upper contact of relay R_{13} a circuit is established from ground, conductor 24, to point 25 where the circuit divides, one branch extending through windings of relays R_{14} and R_{15} and battery B_7, and the other branch through windings of relays R_{16} and R_{17} and the battery B_8, thereby effecting the operation of all of the said relays. As the result of the operation of relays R_{14} and R_{15}, network 5 is connected into the two-wire branch 1 of the four-wire circuit, and as the result of the operation of relays R_{16} and R_{17} network 7 is connected into the two-wire branch 2 of the four-wire circuit. In a similar manner networks 6 and 8 at office Y will be connected into the two-wire branches, 1 and 2, respectively, of the four-wire circuit, when the plug P_3 of the cord circuit at office Y has been connected with the line L_4, which represents a short haul trunk, similar to line L_2.

If the operator at office X, for example, desires to supervise the completed through-line connection by throwing key K_1, to its talking position, the winding of relay R_{11} will be grounded thereby, thus causing the operation of the said relay which in turn results in the opening of the contacts 15, 16 and 17. Through the opening of contact 16, battery B_2 is disconnected from the winding of relay R_6 and marginal relay R_7 is deenergized thereby. Contact 18 of relay R_7 is thereby opened which results in the reconnection of network 9 with the two-wire terminal of the four-wire circuit, thus preventing the singing of the repeater during the time in which the operator is supervising the connection. As soon as the key K_1 is restored to its normal position, relay R_{11} is deenergized, and through the closing of its

normal contacts, the marginal relay R_7 is again operated which results in the disconnection of the network 9 thereby restoring the through-line connection to the position for maximum operating efficiency.

When the subscribers' lines have been disconnected at the distant ends of trunk lines L_2 and L_4 the operators at X and Y remove the plugs of their cord circuits from the lines L_2 and L_4 and the terminals of the four-wire circuit. When the plug P_1 is disconnected from the jack J_3 at office X relays R_7 and R_8 are thereby deenergized, thus allowing their contacts to open which results in the reconnection of network 9 with the two-wire terminal of the four-wire circuit and also results in the deenergization of relay R_{13}, thereby causing the disconnection of networks 5 and 7 from the two-wire branches 1 and 2, respectively, of the four-wire circuit. In a similar manner the removal of plug P_2 from jack J_4 at office Y results in the reconnection of network 10 with the two-wire terminal of the four-wire circuit and in the disconnection of networks 6 and 8 from the two-wire branches 1 and 2, respectively, of the four-wire circuit. It will be seen, therefore, that this invention provides the means for varying the transmission equivalent of the four-wire repeater circuit whereby the transmission equivalents of all through-line telephone connections which are established over the said four-wire repeater circuit may be made substantially uniform.

Although this invention has been shown as embodied in a particular form, it is evident that it is capable of embodiment in other and different forms without departing from the spirit of the appended claims.

What is claimed is:

1. In a signalling system the combination of a four-wire transmission circuit having a plurality of telephone repeaters associated therewith, a plurality of trunk circuits, cord circuits adapted to connect each trunk circuit with the said four-wire circuit, a network at each end of said four-wire circuit having electrical characteristics simulating those of said trunk circuits, and a second network arranged to balance the said first network when a trunk circuit is disconnected from the said four-wire circuit.

2. In a signalling system the combination of a four-wire transmission circuit having a plurality of telephone repeaters associated therewith, a plurality of trunk circuits, cord circuits adapted to link said trunk circuits with said four-wire circuit, a network having electrical characteristics simulating those of said trunk circuits, a second network normally connected with said four-wire circuit adapted to balance the said first network, and means controlled by said cord circuit whereby said second network may be electrically disconnected from said four-wire circuit whenever said trunk is connected with said four-wire circuit and all keys of said cord circuit are in their normal position.

3. In a signalling system combination, a four-wire transmission circuit having a plurality of repeaters associated therewith, a plurality of trunks adapted to be connected with said transmission circuit, a plurality of cord circuits adapted to connect said trunk circuits with said transmission circuit, a network at each end of said four-wire circuit adapted to balance said trunks, a second network normally connected with said transmission circuit adapted to balance said first network when said trunk is disconnected from the transmission circuit and means associated with said cord circuit operable by said keys whereby the said second networks may be automatically connected or disconnected from said transmission circuit

4. In a signalling system the combination of a four-wire transmission circuit having a plurality of repeaters associated therewith, a plurality of trunks adapted to be connected with said four-wire circuit, a plurality of cord circuits adapted to connect said trunks with said four-wire circuit, a network at each end of said four-wire circuit adapted to balance electrically any of said trunks, a second network at each end of said four-wire circuit normally effectively connected thereto adapted to balance said first mentioned network and switching means associated with each second network and controlled by the associated cord circuit whereby said second network may be effectively removed from the four-wire circuit whenever a trunk circuit is connected with the four-wire circuit.

5. In a signalling system the combination of a four-wire transmission circuit having a plurality of repeaters associated therewith, a plurality of trunks adapted to be connected with said four-wire circuit, a plurality of cord circuits adapted to connect said trunks with said four-wire circuit, a network at each end of said four-wire circuit adapted to balance electrically any of said trunks, a second network at each end of said four-wire circuit normally effectively connected thereto adapted to balance said first mentioned network when the four-wire circuit is disconnected from other circuits, and means to disconnect effectively said second network when a trunk circuit is connected thereto by means of one of said cord circuits and all keys of said cord circuit are in their normal position.

6. In a signalling system the combination of a four-wire transmission circuit having a plurality of repeaters associated therewith, a plurality of trunks adapted to be con-

nected with said four-wire circuit, a plurality of cord circuits adapted to connect said trunks with said four-wire circuit, a network at each end of said four-wire circuit adapted to balance electrically any of said trunks, a second network at each end of said four-wire circuit normally effectively connected thereto adapted to balance said first mentioned network when the said four-wire circuit is connected to one end of said cord circuit and the other end is disconnected from said trunk, and means to disconnect said second network when a trunk circuit is connected thereto by means of one of said cord circuits and all keys of said cord circuit are in their normal position.

7. In a signalling system the combination of a four-wire transmission circuit having a plurality of repeaters associated therewith, a plurality of trunks adapted to be connected with said four-wire circuit, a plurality of cord circuits adapted to connect said trunks with said four-wire circuit, a network at each end of said four-wire circuit adapted to balance electrically any of said trunks, a second network at each end of said four-wire circuit normally effectively connected thereto adapted to balance said first mentioned network when one of the keys of the said cord circuit has been operated after said four-wire circuit has been connected with one of said trunks, and means to disconnect said second network when said key has been restored to its normal position.

8. In a signalling system the combination of a four-wire transmission circuit having a plurality of repeaters associated therewith, a plurality of groups of trunks adapted for connection with said four-wire circuit, cord circuits to effect such connection, a plurality of artificial lines adapted to be connected with each of the two-wire branches of the four-wire circuit, means controlled by the connection of the cord circuit with any trunk of one group whereby said artificial lines may be connected into the four-wire circuits, thereby reducing the transmission gain of the four-wire circuit.

9. In a signalling system the combination of a four-wire transmission circuit having a plurality of repeaters associated therewith, a plurality of groups of trunks adapted for connection with said four-wire circuit, cord circuits to effect such connection, a plurality of artificial lines adapted to be connected with each of the two-wire branches of the four-wire circuit, and means associated with the sleeves of the jacks in which the said trunk circuits terminate, whereby the magnitude of the current for operating the relays associated with said artificial lines may be controlled.

In testimony whereof, I have signed my name to this specification this 7th day of August, 1919.

CHARLES S. DEMAREST.