J. F. TOOMEY AND C. S. DEMAREST.

TRANSMISSION CONTROLLING MEANS FOR FOUR-WIRE REPEATERS.

APPLICATION FILED OCT. 16, 1917.

1,318,937.

Patented Oct. 14, 1919.

3 SHEETS—SHEET 1.

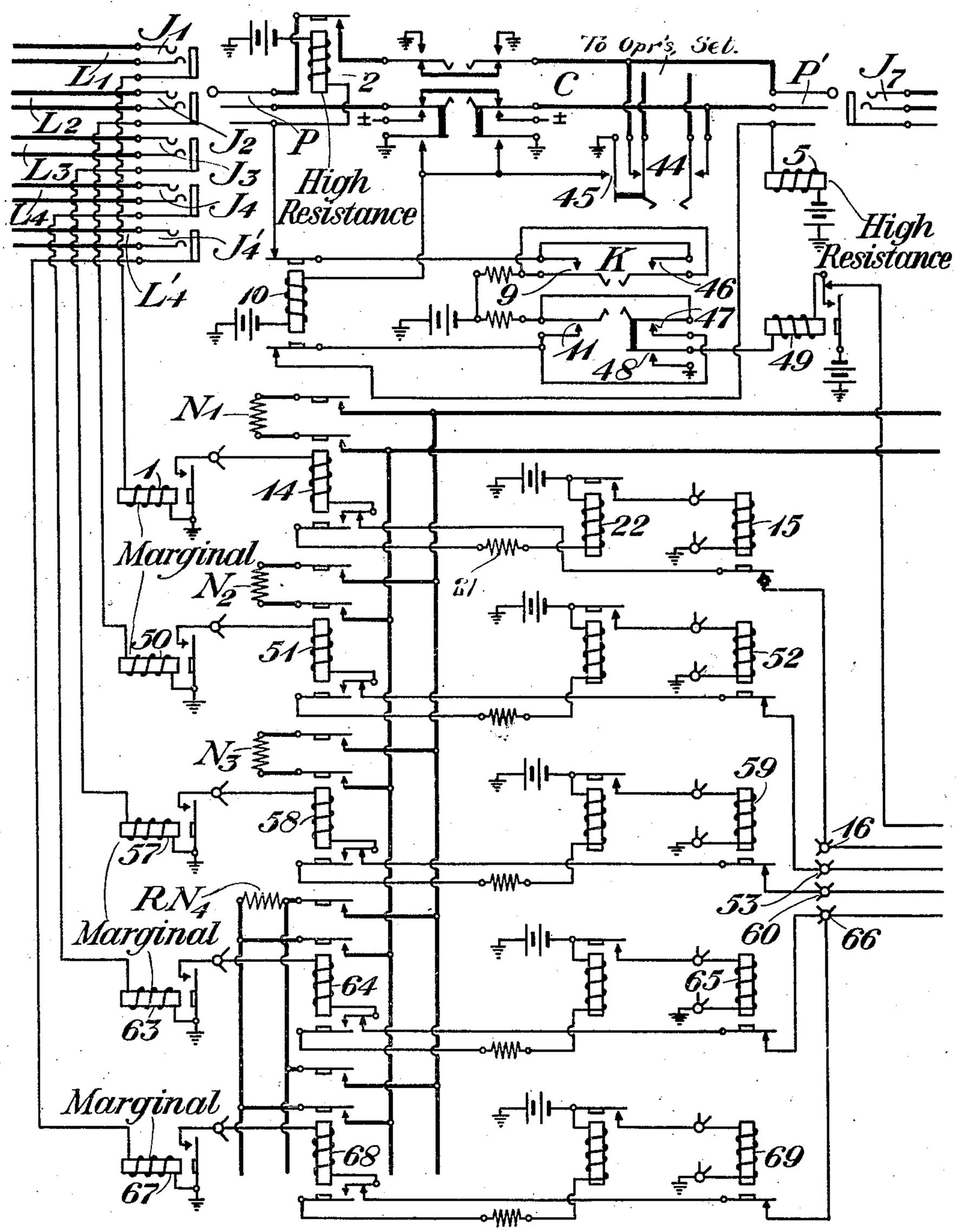

Fig. 1

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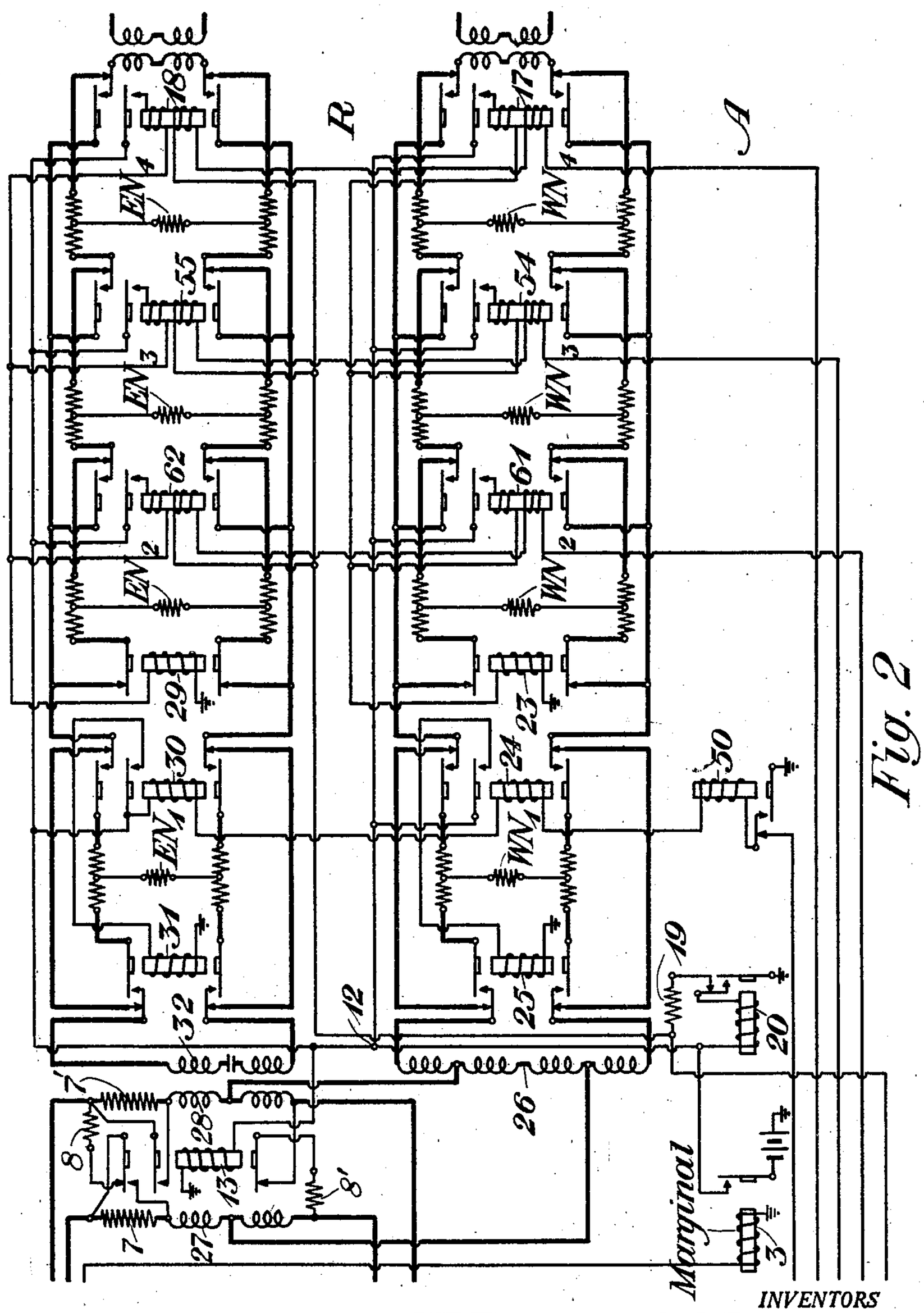

Fig. 2

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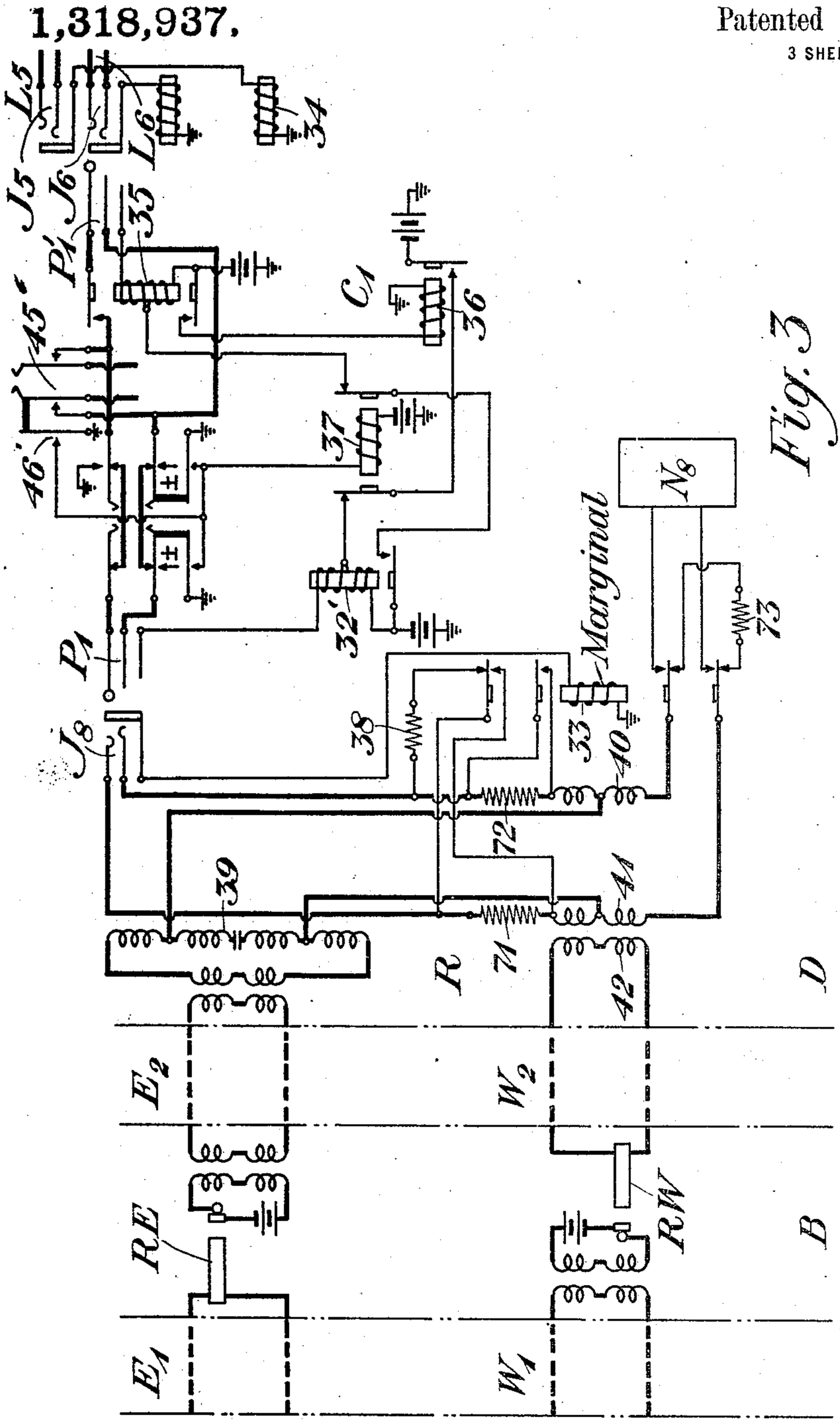

Fig. 3

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UNITED STATES PATENT OFFICE.

JOHN F. TOOMEY, OF NEW YORK, AND CHARLES S. DEMAREST, OF BROOKLYN, NEW YORK, ASSIGNORS TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TRANSMISSION-CONTROLLING MEANS FOR FOUR-WIRE REPEATERS.

1,318,937. Specification of Letters Patent. Patented Oct. 14, 1919.

Application filed October 16, 1917. Serial No. 196,900.

To all whom it may concern:

Be it known that we, JOHN F. TOOMEY and CHARLES S. DEMAREST, residing at New York city and Brooklyn, respectively, in the counties of New York and Kings, respectively, and State of New York, have invented certain Improvements in Transmission-Controlling Means for Four-Wire Repeaters, of which the following is a specification.

This invention relates to transmission circuits, and more particularly to transmission circuits of the type known as four-wire repeater circuits. One of the principal objects of the invention consists in the provision of instrumentalities whereby the transmission over a circuit of this type may be controlled, although the invention is equally applicable to transmission circuits of any other type.

In a four-wire repeater system as usually constructed, two distant stations are connected by two separate transmission lines, one line being arranged to transmit signals in one direction, and the other line being arranged to transmit signals in the opposite direction. In order to offset the attenuation due to the length and electrical properties of the transmission lines, and, if desired, to cause a transmission gain over the four-wire circuit, one way repeaters may be inserted in each line at suitable points. At the terminal stations the four-wire circuit may be connected to ordinary two-wire lines leading from said terminating stations. Inasmuch as the impedance of an operator's set may be materially different from that of the two-wire lines leading from terminating stations, the transmission efficiency should be different when the four-wire circuit is connected to an operator's set, from the transmission efficiency when the circuit is connected to a two-wire line. In accordance with this invention means have been provided to control the transmission efficiency of the four-wire circuit in accordance with the circuit to which it is connected. Furthermore, the impedance of the various two-wire lines leading from a terminating station of the four-wire system may vary considerably. It is, therefore, desirable that the transmission over the four-wire circuit be varied in accordance with the particular type of two-wire line to which it is connected. The invention therefore, contemplates the provision of means whereby the transmission over the four-wire circuit may be adjusted in accordance with the two-wire circuit to which it may be connected. Preferably the means whereby this adjustment is obtained should be automatic, although the adjustment may be secured either in whole or in part by manual manipulations, if desired.

When a four-wire circuit is connected to a two-wire circuit it is desirable that the two-wire circuit be balanced by means of an artificial line or net-work, and as the impedances of the lines vary, net-works should be provided having an impedance such that the various lines may be properly balanced. As the number of artificial lines required may in many instances be less than the number of two-wire lines it is sometimes advantageous to provide equipment whereby the proper artificial line to balance a given two-wire line may be automatically selected. In accordance with this invention the means for automatically adjusting the transmission over the four-wire circuit is arranged in conjunction with a means for the automatic selection of an artificial line, although the transmission adjustment means may be used either with or without the automatic net-work selecting feature. The particular means herein illustrated for the automatic selection of the net-work is the relay selecting circuit of the type illustrated and described in the co-pending application of C. S. Demarest, Serial No. 174,886, filed June 15, 1917. It should be understood, however, that any suitable means for selecting the net-work may be used.

The particular means shown for adjusting the transmission efficiency of the four-wire circuit consists in a plurality of net-works which may be connected in each transmission line of the four-wire circuit by means of controlling relays. As shown, there are four steps of the adjustment, although any number of steps desired might be provided for. As the number of two-wire terminating lines may be greater than the number of steps in the adjustment of the transmission, the lines are grouped so that when the four-wire circuit is connected to any line of the same group the same adjustment of the transmission is secured. The lines may also be grouped in ac-

cordance with the type of net-work necessary to balance the same. As shown, the grouping of the lines is the same both for the selection of artificial lines and for the adjustment of the transmission efficiency of the four-wire circuit, but it should be understood that the grouping need not be the same for both purposes.

The invention will now be more fully understood by a reference to the following description taken in connection with the accompanying drawings, Figures 1, 2 and 3 of which constitute a circuit diagram of an embodiment of the invention in which one end of the four-wire circuit is equipped with means for the automatic selection of artificial balancing lines and for the automatic adjustment of the transmission of the four-wire circuit in accordance with the character of the two-wire line to which it is connected. The other end of the four-wire circuit is illustrated as being provided only with a means for adjusting the transmission of the four-wire circuit so as to secure the desired transmission when the circuit is connected to an operator's set or to a terminating two-wire line. It will be understood, however, that in practice both ends of the four-wire circuit may be provided with the same type of apparatus, the terminating apparatus being shown different at the two ends in the drawings in order to illustrate two different embodiments of the invention. In order that the circuit diagram may be more clearly understood the sheet upon which Fig. 1 is placed should be arranged vertically, while the sheets upon which Figs. 2 and 3 are placed should be arranged end to end with Fig. 2 at the right of Fig. 1.

Referring to the drawings, three stations, A, B and D are shown. Stations A and D are connected by transmission lines E_1 and E_2 for transmission in one direction, and by lines W_1 and W_2 for transmission in the opposite direction, the two sets of lines thus forming a four-wire circuit interconnecting the two stations. At station B one-way repeaters RE and RW are inserted between lines E_1 and E_2 and W_1 and W_2 respectively. It will be understood, of course, that the repeaters may be arranged at any desired point or points in the lines interconnecting the stations A and D. It will also be understood that while the repeaters shown are of the so-called mechanical type, repeaters of the vacuum tube type or of any other well-known type may be used.

At station A the four-wire circuit terminates in a jack J_7 whereby a terminating two-wire line may be connected to the four-wire circuit. At station D the four-wire circuit terminates in a jack J_8 for a similar purpose. Two wire lines L_1, L_2, L_3, L_4 and L'_4 are shown terminating in jacks J_1, J_2, J_3, J_4 and J'_4 at station A. A cord circuit C terminating in plugs P and P′ is provided at station A for interconnecting any one of the two-wire lines at said station with the four-wire circuit R. Lines L_5 and L_6 terminate in jacks J_5 and J_6 at station D, and a cord circuit C_1 terminating in plugs P_1 and P'_1 is provided for interconnecting any one of said lines with the four wire repeater R.

At station A artificial lines N_1, N_2 and N_3 individual to lines L_1, L_2 and L_3 are provided to balance said lines, while an artificial line RN_4 adapted to balance either line L_4 or L'_4 is provided, said artificial line being individual to the four wire repeater R. A relay selecting arrangement such as that shown and described in the application of C. S. Demarest above referred to is also provided at station A for the purpose of selecting and connecting the proper net-work with the four-wire circuit to balance the two-wire line with which it is associated.

In order to secure the desired adjustment of the transmission over the four-wire circuit three net-works are provided at station A in each transmission line of the four-wire circuit. Net-works EN_2, EN_3 and EN_4 are provided for transmission line E_1, while net-works WN_2, WN_3, WN_4 are provided for line W_1. One or more of these net-works may be connected in the transmission circuit by means of suitable controlling relays depending upon the character of the line to which the four-wire circuit is connected. If for any reason the transmission gain due to the four-wire circuit when connected with any line is too great, means are provided whereby an operator may connect net-works EN_1 and WN_1 in lines E_1 and W_1 respectively, thereby reducing the normal transmission efficiency for that particular connection by a fixed amount.

At station A, in order to balance the four-wire circuit when no terminal apparatus is associated with the two-wire terminals thereof and no balancing artificial line is connected, an impedance arrangement comprising series resistances 7 and 7′ and a shunt resistance 8 is connected to the line side of the induction coil comprising windings 27, 28 and 32, while a shunt impedance element 8′ is connected across the artificial line side of the induction coil. These impedance elements are so proportioned that if an operator's set is bridged across the two-wire line, or a terminating two-wire line and an operator's set are associated with the four-wire circuit, the combination consisting of the impedance arrangement 7, 7′ and 8 together with the operator's set, or operator's set and line as the case may be, will be approximately balanced by the impedance element 8′ so that the operator may talk or signal over the four-wire circuit. When, however, a two-wire line is connected

to the four-wire circuit with the operator's set disconnected, the impedance arrangement 7, 7′ and 8 together with impedance element 8′ will be disconnected, a suitable artificial line to balance the terminating two-wire line being simultaneously selected and connected in circuit.

A similar arrangement is provided at station D, an impedance arrangement comprising series resistances 71 and 72, and shunt resistance 38 being connected in the line side of the induction coil comprising windings 40, 41 and 42, while an impedance element 73 is connected across the artificial line side. These arrangements approximately balance the circuit when idle, or when an operator's set is associated therewith either alone or in shunt with a terminating two-wire line. When, however, a terminating two-wire line is connected to the system with no operator's set associated therewith, the impedance arrangements above described are disconnected and an artificial line or net work N_8 is connected to the four-wire system to balance the line. As shown but one artificial line is provided to balance the terminating lines, but it will be understood that the circuit may be equipped with artificial line selecting arrangements at station D as well as station A if desired.

With this general description in mind the invention may now be fully understood from a description of the operation. Assuming that it is desired to connect line L_1 at station A and line L_5 at station D to the corresponding ends of the four-wire repeater R, the operator at station A will insert the plugs P and P′ of the cord circuit C in jack J_1 of line L_1 and jack J_7 of the four-wire circuit respectively. Similarly at station D the operator will insert plugs P_1 and P'_1 of cord circuit C'_1 in jacks J_8 and J_5 respectively. Upon inserting the plug P in jack J_1 a circuit is closed from ground through the winding of relay 1, sleeve contacts of jack J_1 and plug P, and the winding of relay 2 to battery, thereby energizing the relay 2, which operates to close the upper strand of the cord circuit at its upper contact. Relay 1 is marginal however, and does not receive sufficient current to energize its winding in series with the high resistance of relay 2. Upon inserting plug P′ in jack J_7 a circuit is closed from ground through the winding of relay 3, sleeve contacts of jack J_7 and plug P′ and through the winding of relay 5 to battery, energizing relay 5. Relay 3, like relay 1 is marginal, and is not energized over this circuit.

Normally the terminating conductors of the four-wire circuit leading to the tip and ring terminals of jack J_7 are connected to the impedance arrangement consisting of resistances 7, 8 and 7′, and resistance 8′ is shunted across the artificial line side of the circuit. This results in terminating circuits for the two-wire part of the system of such impedance as to substantially prevent unbalance and permit of sufficient transmission gain for all conditions excepting when the through connection to the two-wire line is established. If the operator's set is bridged across the cord circuit by key 44, a satisfactory balance will be maintained regardless of whether a terminating two-wire line such as L_1 be connected. In order to complete the connection the operator restores her listening key and throws controlling key K of the cord circuit C to the left, thereby connecting battery through a low resistance to the sleeve conductor of plug P over contact 9 of said key and the upper back contact of relay 10, whereby the current flow through the winding of relay 1 is increased by an amount sufficient to energize said relay. Battery is also applied through a low resistance to the sleeve contact of plug P′ over contact 11 of key K and the lower back contact of relay 10, thereby increasing the current flow through the winding of relay 3 by an amount sufficient to energize said relay. A circuit is closed from battery over the front contact of relay 3 and through the winding of relay 13. Relay 13 is thereby energized and opens the shunt through resistances 8 and 8′ and shunts the series resistances 7 and 7′ in the terminating conductors of the four-wire circuit, thereby changing the transmission efficiency to a value suitable for a connection over a two-wire line.

Upon the energization of relay 1 a momentary circuit is closed from ground over the front contact of said relay through the winding and back contact of relay 14, back contact of relay 15 to point 16, and thence through the lower winding of relays 17 and 18 in series, through resistance 19, back contact and winding of relay 20 and front contact of relay 3 to battery. Relays 14, 17, 18 and 20 are energized over this circuit. Relay 14 at its upper contacts operates to connect artificial line N_1 to the repeater circuit to balance line L_1 and at its lower contact disconnects its winding from the selecting circuit just traced at the same time closing a locking circuit from ground over contact of relay 1, winding and front contact of relay 14, through the resistance 21 and winding of relay 22 to battery. Relay 22 is energized and closes a circuit through relay 15 individual to the four-wire circuit R and through the windings of similar relays not shown in parallel to the relay 15 and individual to other four-wire circuits. Relay 15 and the corresponding relays of other four-wire circuits are energized to open the initial energizing circuit of relay 14 which is individual to the four-wire circuit R and similar relays individual to other four-wire

circuits to prevent the selection of the artificial line N_1 by any other four-wire circuit. Relay 20, upon being energized, disconnects its own winding from the selecting circuit above described and closes a locking circuit from battery over the contact of relay 3 and through the winding and front contact of relay 20 to ground. Relay 17, upon being energized, at its middle contact closes a locking circuit from ground through the winding of relay 23, locking winding and front middle contact of relay 17 to point 12, and thence over the front contact of relay 3 to battery. Relays 17 and 23 are now energized and at their upper and lower contacts disconnect series net-works WN_2, WN_3 and WN_4 from the talking conductors of line W_1. Relay 17 at its upper and lower front contacts completes the talking circuit of the line W_1 over said contacts and the upper and lower back contacts of relays 24 and 25 through the winding of auto transformer 26 to the midpoints of windings 27 and 28 of a three-winding induction coil connected in circuit with the two-wire line L_1 and the artificial line N_1. It will thus be seen that the line W_1 is connected to the two-wire line L_1 without the interposition of any transmission controlling net-work. Upon the energization of relay 18 a locking circuit is also closed by said relay from ground through the winding of relay 29 and through the locking winding and middle front contact of relay 18 to point 12, and thence over the front contact of relay 3 to battery. Relays 18 and 29 are now energized and at their upper and lower contacts disconnect the net-works EN_2, EN_3 and EN_4 from the line E_1. The relay 18 at its outer front contacts closes a direct connection from the line E_1 over the upper and lower back contacts of relays 30 and 31 to the terminals of the winding 32 of the three-winding transformer, whereby the line E_1 is inductively connected to the line L_1 without the interposition of any transmission controlling net-works.

The talking connection at station A is now completed. Returning to station D upon the insertion of the plug P_1 in jack J_8 of the four-wire system a circuit is closed from ground through the winding of relay 33, sleeve contacts of jack J_8 and plug P_1 and through both windings of relay 32′ to battery. Relay 32′ is energized but relay 33 is marginal and does not pull up its armature. Upon inserting plug P'_1 in jack J_5 a circuit is closed through the winding 34, sleeve contacts of jack J_5 and plug P'_1 and through both windings of relay 35 to battery. Relay 35 is energized over this circuit and at its lower contact closes a circuit through the winding of relay 36. Relay 36 upon being energized short circuits the lower winding of relay 32′ over a path from battery, front contact of relay 36 and left-hand back contact of relay 37, whereby the resistance in series with relay 33 is reduced so that said relay receives a sufficient amount of current to energize its winding. Similarly relay 32′, upon being energized short circuited the lower winding of relay 35 over a path from battery, front contact of relay 32′ and back contact of relay 37. The relay 33, upon being energized opens the shunt path through resistances 38 and 73, normally bridged across the terminal conductors of the four-wire circuit R at station D, and short circuits resistances 71 and 72, at the same time connecting artificial line N_8 in circuit. With these impedance arrangements in circuit a balance is obtained such that the transmission over the four-wire circuit is satisfactory for any condition in which the operator's set is bridged across the two-wire terminals of the system, whether a two-wire line be associated therewith or not. When said shunt and series resistances are removed, which occurs only when both plugs P_1, and P'_1 are inserted in the corresponding jacks with the talking and ringing keys of the cord circuit normal, so that a two-wire line is connected to the four-wire circuit, the transmission is increased to a value suitable for the through connection with a terminating two-wire line.

A talking connection is now established between lines L_1 and L_5 over the four-wire circuit R. The incoming signals from line L_1 are transmitted over the cord circuit C to the terminating conductors of the four-wire circuit R at station A, and thence through the windings 27 and 28 to the artificial line N_1. The current flow through windings 27 and 28 induces similar currents in winding 32 whereby the signals are transmitted over the back contacts of relay 31 and 30 and the front contacts of relay 18 to the line E_1 and over said line to the repeater RE. The repeater RE amplifies the signaling currents which are then transmitted over the line E_2 and through windings of an auto transformer 39 to the midpoints of windings 40 and 41 of a three-winding induction coil. The circuit divides at this point, one-half of the energy being transmitted to the artificial line N_8 and the other half being transmitted over the cord circuit C_1 to the line L_5. Since the incoming energy from the auto transformer 39 flows through the two halves of the windings 40 and 41 in opposite directions, if artificial line N_8 properly balances the line L^5 substantially no energy is applied to the line W_2 through the winding 42 of the three-winding induction coil. Similarly incoming signals from line L_5 are transmitted over the cord circuit C_1 to the terminating conductors of the

four-wire circuit R at station D and through the windings 40 and 41 to the artificial line N_s. The current flow through windings 40 and 41 is now in series and induces similar currents in the winding 42 whereby the signals are transmitted over the line W_2 to the repeater RW. The repeater RW now amplifies the signals which are then transmitted over the line W_1 and over the front contacts of relay 17 and the back contacts of relays 24 and 25 through the auto transformer 26 and to the midpoints of the windings 27 and 28 where the energy divides, one-half being transmitted to the artificial line N_1, the other half over the cord circuit C to the line L_1. If the line L_1 is properly balanced by net-work N_1 substantially no energy is transmitted through the winding 32 back to the station D.

If the operator at station A should throw one of her controlling keys such as the listening key 44 of the cord circuit C, a circuit will be closed over the contact 45 of said key through the winding of relay 10 which upon being energized, at its upper and lower contacts opens the circuits previously traced whereby battery was applied directly to the sleeve contacts of plugs P and P'. The potential over these contacts is now reduced so that relays 1 and 3 are deënergized. Relay 1 opens the locking circuit through relay 14 and relay 22 so that these relays are deenergized, relay 14 disconnecting the artificial line N_1 from the repeater and relay 22 opening the circuit of relay 15 and similar relays of other four-wire circuits. Upon deenergization of relay 3 the locking circuit previously traced through relay 20 is opened and said relay restored to normal. The deenergization of relay 3 also opens the circuit previously traced through relay 13 which again bridges resistances 8 and 8' and connects the series resistances 7 and 7' to the terminating conductors of the four-wire circuit to reduce the transmission to a value suitable for terminal connections at station A not involving two wire lines. The deenegization of the relay 3 also operates to open the locking circuits previously traced through the windings of relays 17, 23, 18 and 29 which are thereby deënergized, and the connection of the transmission controlling net-works restored to normal. Similarly if the operator at station D throws one of her controlling keys such as the listening key 45' of cord circuit C, the circuit is completed over contact 46' of said key through the winding of relay 37 to battery, whereby said relay is energized, and at its right and left-hand contacts opens the short circuits previously traced for the lower windings of relays 32' and 35. The potential over the sleeve contacts of plugs P_1 and jack J_s is now reduced so that relay 33 is deënergized, and the shunt resistances 38 and 73 and series resistances 71 and 72 are connected to the terminating conductors of the four-wire circuit. This reduces the transmission efficiency to a value suitable for terminal connections at station D not involving two-wire lines.

If, when the connection previously described was completed between lines L_1 and L_5 it should be found that the transmission between said stations over the four-wire circuit is too great, the operator may throw key K to the right instead of to the left, thereby closing contacts 46 and 47. As these contacts are connected in parallel with contacts 9 and 11 of key K the circuits already described are again closed whereby the net-work N_1 is selected and connected to the repeater and the transmission controlling net-works disconnected from the four-wire line. When key K is thrown to the right an additional contact 48 is closed whereby a circuit is completed through the winding and back contact of relay 49, back contact and winding of relay 50, windings of relays 24 and 30 to point 12 and thence over the front contact of relay 3 to battery. Relays 49, 50, 24 and 30 are thereby energized, relay 49 opening the momentary circuit just traced and locking itself over its front contact. Relay 50 also opens the momentary circuit just closed and at its front contact completes a locking circuit from ground over the front contact and through the winding of relay 50, through windings of relays 24 and 30 to point 12, and thence over the front contact of relay 3 to battery. Relays 50, 24 and 30 are maintained energized over this circuit. Relay 24, at its middle contact closes a circuit from ground through the winding of relay 25 over the front middle contact of relay 24 to point 12 and thence over the contact of relay 3 to battery. Relays 24 and 25 at their upper and lower front contacts introduce a net-work WN_1 in the connection between the line W_1 and the terminating conductors of the four-wire circuit. Similarly relay 30 closes a circuit from ground through the winding of relay 31, front middle contact of relay 30 to point 12 and thence over front contact of relay 3 to battery. Relays 30 and 31 at their upper and lower front contacts interpolate a net-work EN_1 in the connection between the line E_1 and the terminating conductors of the four-wire circuit. The inclusion of these two net-works in series with the lines E_1 and W_1 reduces the transmission over the four-wire circuit an arbitrary amount sufficient to prevent the undesirable result due to too great a transmission.

Upon taking down the connection the plugs P and P' are withdrawn from the corresponding jacks, thereby deënergizing re-

lays 1, 2, 3 and 5 and restoring the circuits controlled by said relays to normal in a manner already described. Upon withdrawing plugs P_1 and P'_1 from jacks J_8 and J_5 at station D, relays 32′, 33, 34, 35 and 36 are de-energized and the apparatus controlled thereby restored to normal.

If the plug P had been inserted in jack J_2 of line L_2 instead of jack J_1, upon the operation of the key K relay 50 would have been energized thereby completing the circuit from ground over the front contact of relay 50, winding and back contact of relay 51, back contact of relay 52 to point 53, and thence through the lower windings of relays 54 and 55, through resistance 19, over the back contact and through the winding of relay 20 and over the front contact of relay 3 to battery. The energization of relay 51 results in the connection of artificial line N_2 to the repeater. Relays 54 and 55 upon being energized complete locking circuits through their upper windings in series with relays 23 and 29 respectively. Relays 23 and 29 operate as before to disconnect net-works WN_2 and EN_2 from the four-wire circuit, while relays 54 and 55 operate to interpolate the net-works WN_4 and EN_4 in the four-wire circuit. The connection of the net-work WN_4 extends from the line W_1 over the back contacts of relay 17 and the front contacts of relay 54 and thence over the circuit previously traced to the terminating conductors of the four-wire circuit. Similarly the connection of net-work EN_4 extends from the line E_1 over the back contacts of relay 18 and the front contacts of relay 55. The inclusion of these net works in the four-wire system reduces the transmission to a value suitable for a connection to the line L_2. If the connection had been to the line L_3 the relay 57 would have been energized. The energization of relay 57 closes a circuit from ground over the front contact of said relay, through the winding and back contact of relay 58, back contact of relay 59 to point 60, and thence through the lower windings of relays 61 and 62, through the resistance 19, back contact and winding of relay 20, and over the front contact of relay 3 to battery. Relay 58 operates to connect net-work N_3 to the repeater while relays 61 and 62 close locking circuits through windings of relays 23 and 29 respectively and interpolate net-works WN_3 and WN_4 in the line W_1 and net-works EN_3 and EN_4 in the line E_1. If the connection had been made to line L_4, relay 63 would have been energized, closing a circuit from ground over the front contact of relay 63, through the winding and back contact of relay 64, over the back contact of relay 65 to point 66 and thence through resistance 19, back contact and winding of relay 20 and over the front contact of relay 3 to battery. Relay 64 operates to connect artificial line RN_4 to the repeater. It will be noted that the circuit just traced did not pass through any of the controlling relays of the transmission controlling net-works, so that net-works WN_2, WN_3 and WN_4 are all three included in line W_1, while net-works EN_2, EN_3 and EN_4 are included in line E_1. The circuit from line W_1 extends over the back contacts of relay 17 through net-work WN_4, over the back contacts of relay 54 through net-work WN_3, over the back contacts of relay 61 through net-work WN_2, over back contacts of relay 23, and thence over circuit previously traced to the terminating conductors of the four-wire system. Similarly the connection from line E_1 extends over the back contacts of relays 18, 55, 62, 29, 30 and 31 to the terminals of coil 32. If the connection had been made to line L'_4, relay 67 would have been energized, thereby closing a circuit from ground over the front contact of said relay, through the winding and back contact of relay 68, back contact of relay 69 to point 66, and thence through resistance 19, back contact and winding of relay 20 and over the front contact of relay 3 to battery. Relay 68 upon energizing also connects the artificial line RN_4 to the repeater. As no transmission controlling relays are operated, the same net-works are included in the four-wire circuit as described in connection with line L_4.

It will be noted that a connection to either line L_4 or line L'_4 produces the same result as far as the selection of an artificial line and the adjustment of the transmission efficiency is concerned. It will be understood that these lines are illustrative of a group having similar characteristics, and while but two lines are shown, any desired number may be provided. It should also be noted that lines L_1, L_2 and L_3 are provided with individual balancing lines N_1, N_2 and N_3 and that a connection to each of these lines results in a different adjustment of the transmission. As other lines having individual net-works or other groups of lines capable of being balanced by a common net-work might require the same transmission adjustment as one or more of the lines illustrated, the selecting circuits controlled by said lines would be connected to one of the terminals 16, 53, 60 or 66, depending upon the adjustment desired.

It will be seen that by means of this invention, the transmission gain due to the connection of two transmission circuits through a repeater may be automatically determined in accordance with the particular circuits connected, thereby eliminating a considerable amount of supervision over connections. While the invention has been disclosed as embodied in certain forms which are considered desirable, it will be under-

stood that various changes may be made in the organization shown, without departing from the spirit of the invention.

What is claimed is:

1. A four-wire transmission circuit extending between widely separated stations, terminal apparatus with which said circuit may be associated, and means to automatically vary the transmission efficiency of said circuit in accordance with the character of the terminal apparatus with which said circuit is associated.

2. A four-wire transmission circuit extending between widely separated stations, a plurality of terminating lines with which said transmission circuit may be associated, and means controlled by said terminating lines to adjust the transmission efficiency of said circuit in accordance with the requirements of the line with which it is associated.

3. A four wire repeater circuit extending between widely separated stations, terminal apparatus with which said repeater circuit may be associated, and means to automatically control the transmission efficiency of said repeater circuit in accordance with the requirements of the terminal apparatus with which it is associated.

4. A four-wire repeater circuit extending between widely separated stations, a plurality of transmission lines with which said repeater circuit may be associated, and means controlled by said transmission lines to adjust the transmission efficiency of said repeater circuit in accordance with the requirements of the line with which it is associated.

5. A repeater circuit extending between widely separated points and comprising a pair of separate transmission circuits one for transmission in each direction and having one way repeaters therein, terminal apparatus with which said repeater circuit may be associated, and means to automatically control the transmission efficiency of said repeater circuit in accordance with the requirements of the terminal apparatus with which it is associated.

6. A repeater circuit extending between widely separated points and comprising a pair of separate transmission circuits one for transmission in each direction and having one way repeaters therein, a plurality of transmission lines with which said repeater circuit may be associated, and means controlled by said transmission lines to adjust the transmission efficiency of said repeater circuit in accordance with the requirements of the line with which it is associated.

7. A repeater circuit extending between widely separated points and comprising a pair of separate transmission circuits one for transmission in each direction and having one way repeaters therein, a plurality of transmission lines with which said repeater circuit may be associated, a plurality of artificial lines for balancing said transmission lines, means for selecting an artificial line to balance the transmission line with which said repeater circuit is associated and means to automatically control the transmission efficiency of said repeater circuit in accordance with the requirements of said transmission line.

8. A repeater circuit extending between widely separated points and comprising a pair of separate transmission circuits one for transmission in each direction and having one way repeaters therein, a plurality of transmission lines with which said repeater may be associated, a plurality of artificial lines to balance said transmission lines, and means controlled by said lines for selecting an artificial line to balance the transmission line with which the repeater circuit is associated and for controlling the transmission efficiency of said repeater circuit in accordance with the requirements of said transmission lines.

9. A repeater circuit extending between widely separated points and comprising a pair of separate transmission circuits one for transmission in each direction and having one way repeaters therein, a plurality of transmission lines with which said repeater circuit may be associated, a plurality of artificial lines to balance said transmission lines, and a relay selecting circuit for controlling the selection of an artificial line to balance the transmission line with which said repeater circuit may be associated and for controlling the transmission efficiency of said repeater circuit in accordance with the requirements of the transmission line with which the repeater circuit is associated.

10. A four wire transmission circuit extending between widely separated stations, a plurality of terminating lines with which said transmission circuit may be associated, means controlled by said terminating lines to adjust the transmission efficiency of said circuit in accordance with the requirements of the line with which it is associated, and means controllable at will to vary the adjustment thus obtained.

11. A repeater circuit, transmission lines with which said repeater circuit may be associated, and automatic means to vary the transmission efficiency of said repeater circuit in accordance with whether it is associated with a transmission line or with a terminal connection of another character.

12. A four-wire transmission circuit extending between widely separated stations, a plurality of terminating lines with which said circuit may be associated, a plurality of relays for variably controlling the transmission efficiency of said circuit, said relays being selectively operated in accordance with the terminating line with which the circuit is associated.

13. A four wire transmission circuit extending between widely separated stations, a plurality of terminating lines with which said circuit may be associated, certain of said lines being grouped, a plurality of relays for variably controlling the transmission efficiency of said circuit, certain of said relays being individual to groups of lines and responsive to the association of said circuit with a line of the group to control said connection.

14. A transmission circuit, terminating lines with which said circuit may be associated, a plurality of impedance elements, a plurality of controlling relays selectively responsive to the association of said circuit with a line, and means controlled by said relays to variably interpolate said impedance elements in the transmission circuit.

15. A transmission circuit, terminating lines with which said transmission circuit may be associated, a plurality of net-works, a plurality of controlling relays selectively responsive to the association of said circuit with a line, and means controlled by said relays to variably introduce said net-works in the transmission circuit.

16. A transmission circuit, terminating lines with which said transmission circuit may be associated, a plurality of impedance elements, and means selectively controlled by the association of said circuit with a line to variably introduce said impedance elements in said circuit.

17. A transmission circuit, terminating lines with which said transmission circuit may be associated, a plurality of net-works and means selectively controlled by the association of said circuit with a line to variably introduce said net-works in said circuit.

In testimony whereof, we have signed our names to this specification this ninth day of October, 1917.

JOHN F. TOOMEY.
CHARLES S. DEMAREST.