C. S. DEMAREST.

RELAY SELECTING CIRCUIT FOR ARTIFICIAL LINES.

APPLICATION FILED JUNE 15, 1917.

1,308,664.

Patented July 1, 1919.

6 SHEETS—SHEET 1.

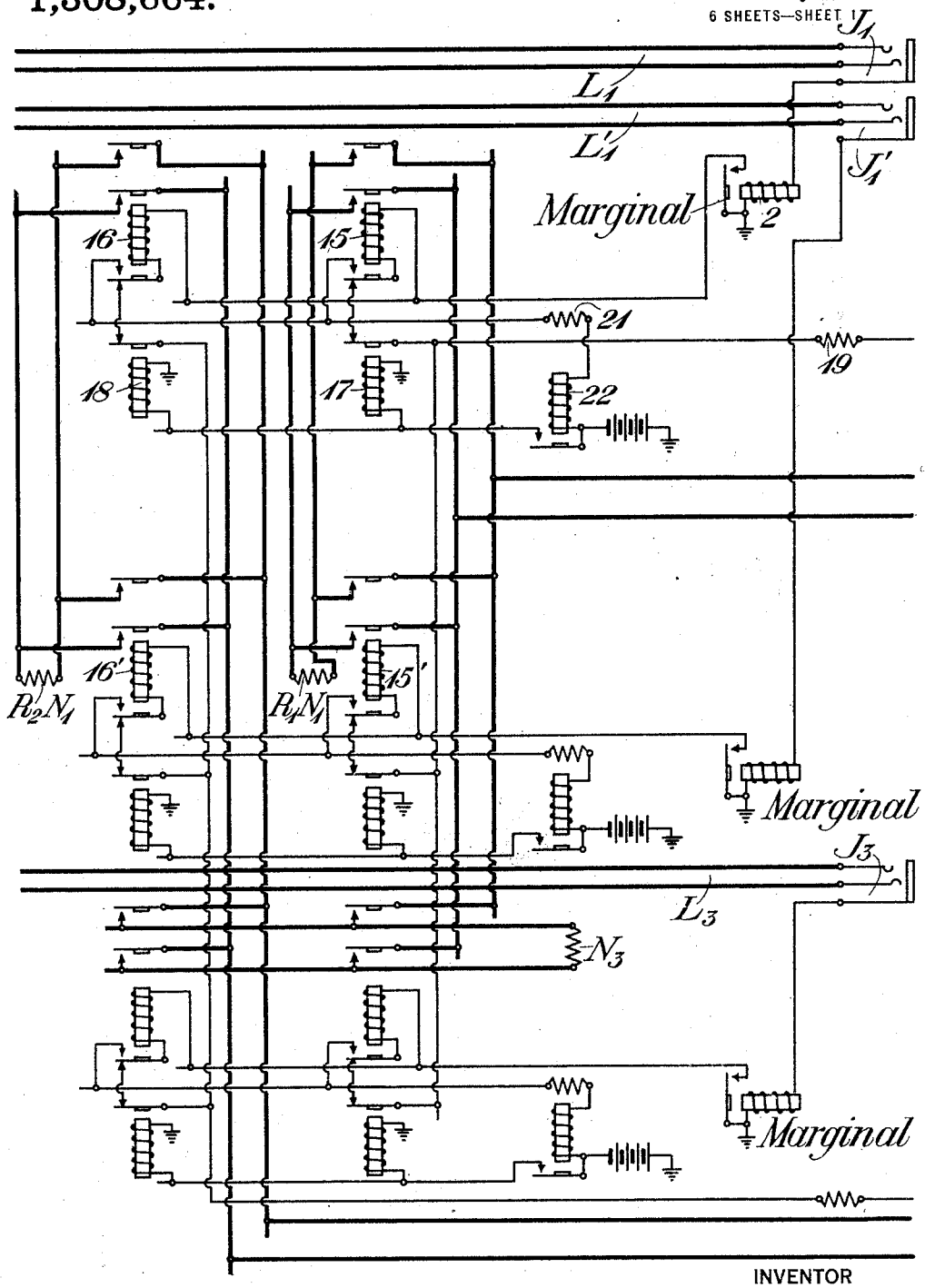

Fig. 1

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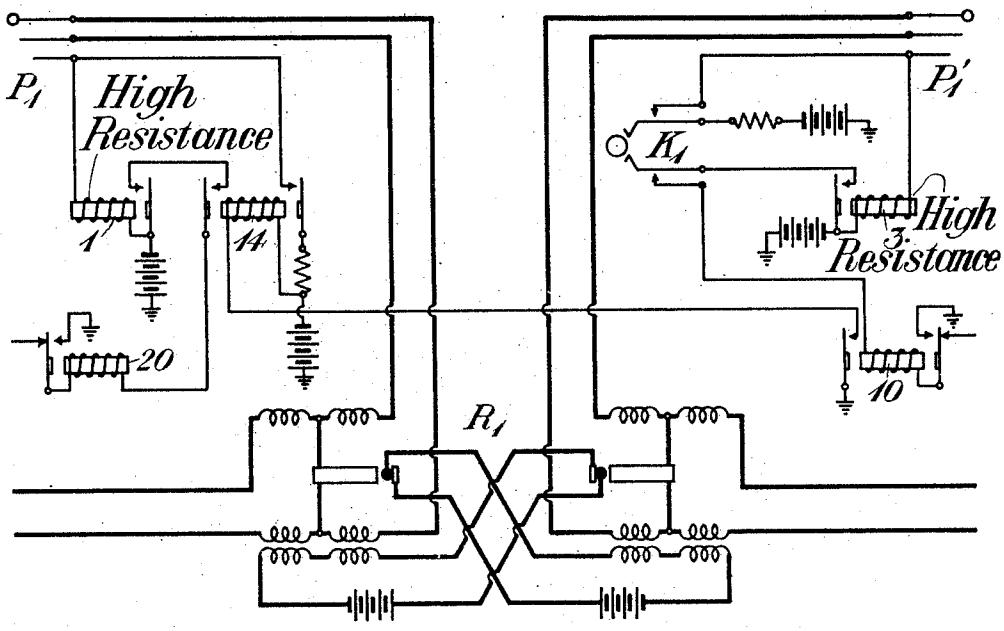
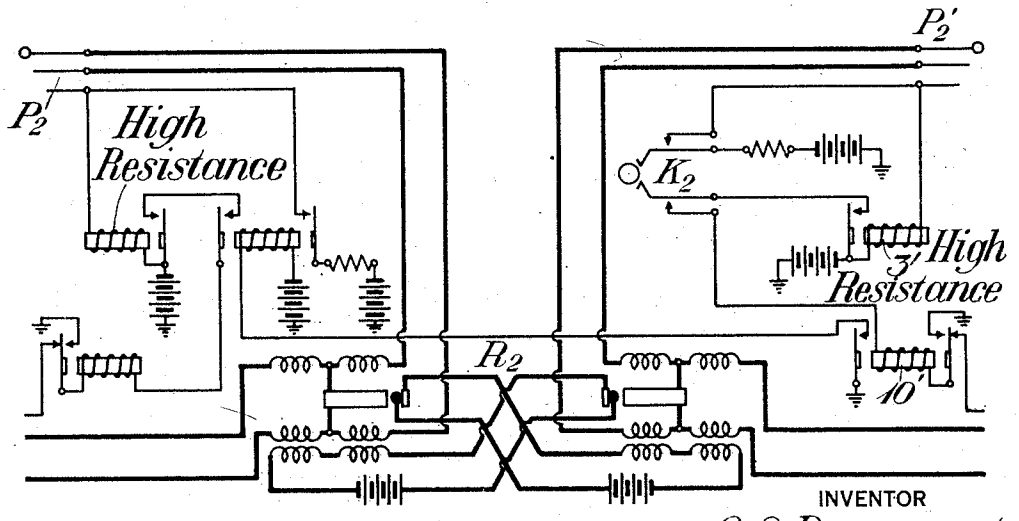


Fig. 2



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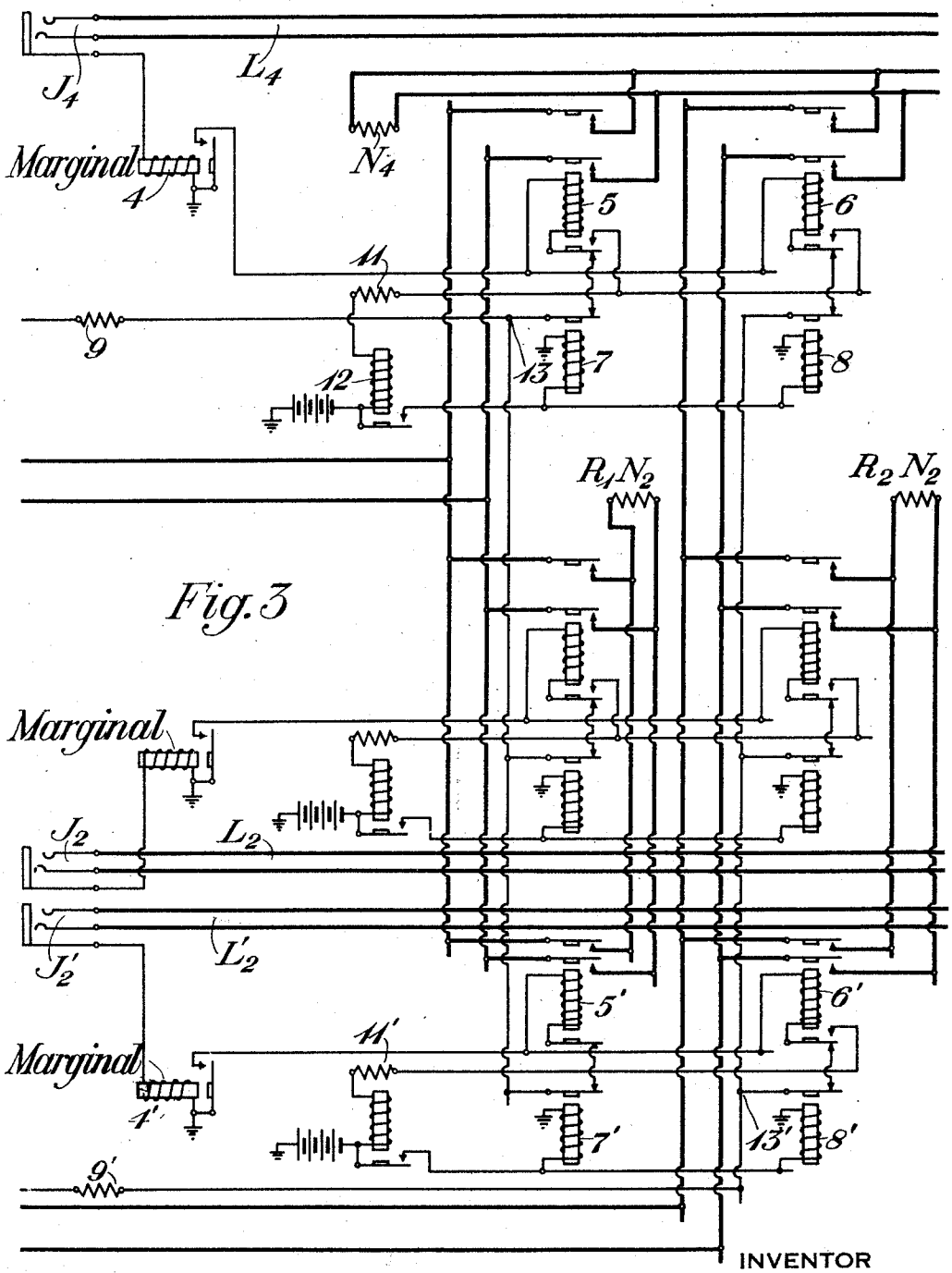

Fig. 3

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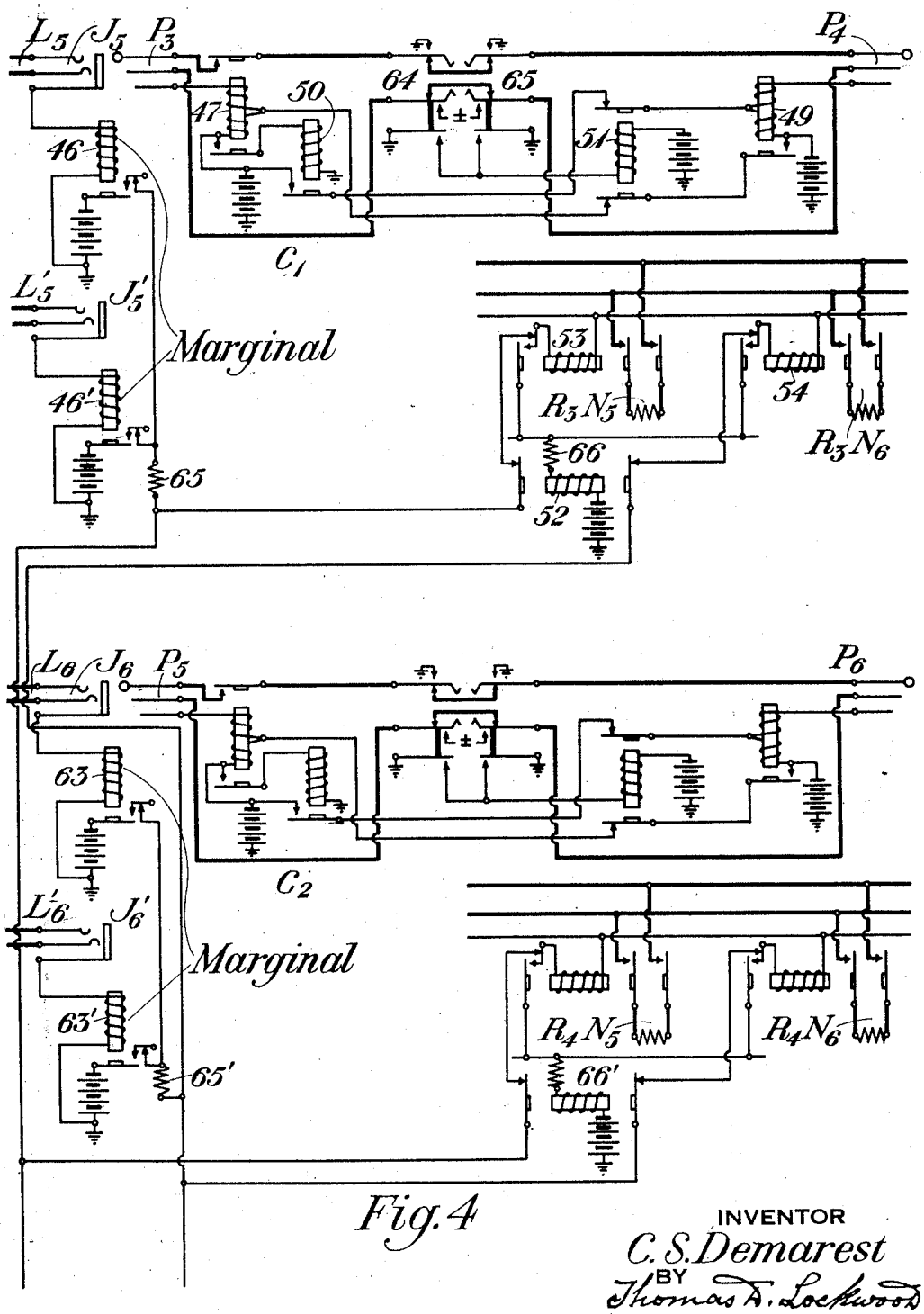

Fig. 4

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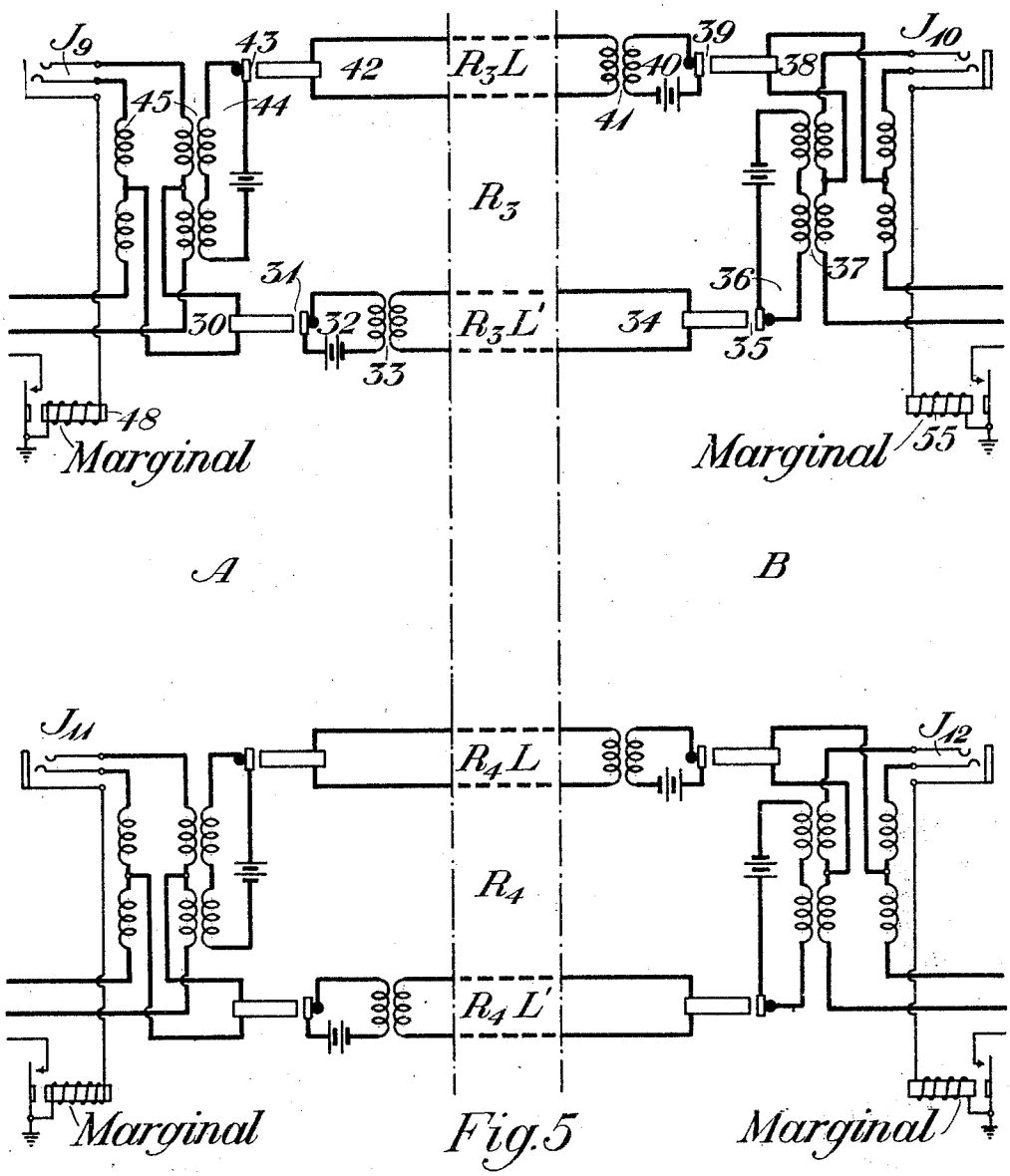

Fig. 5

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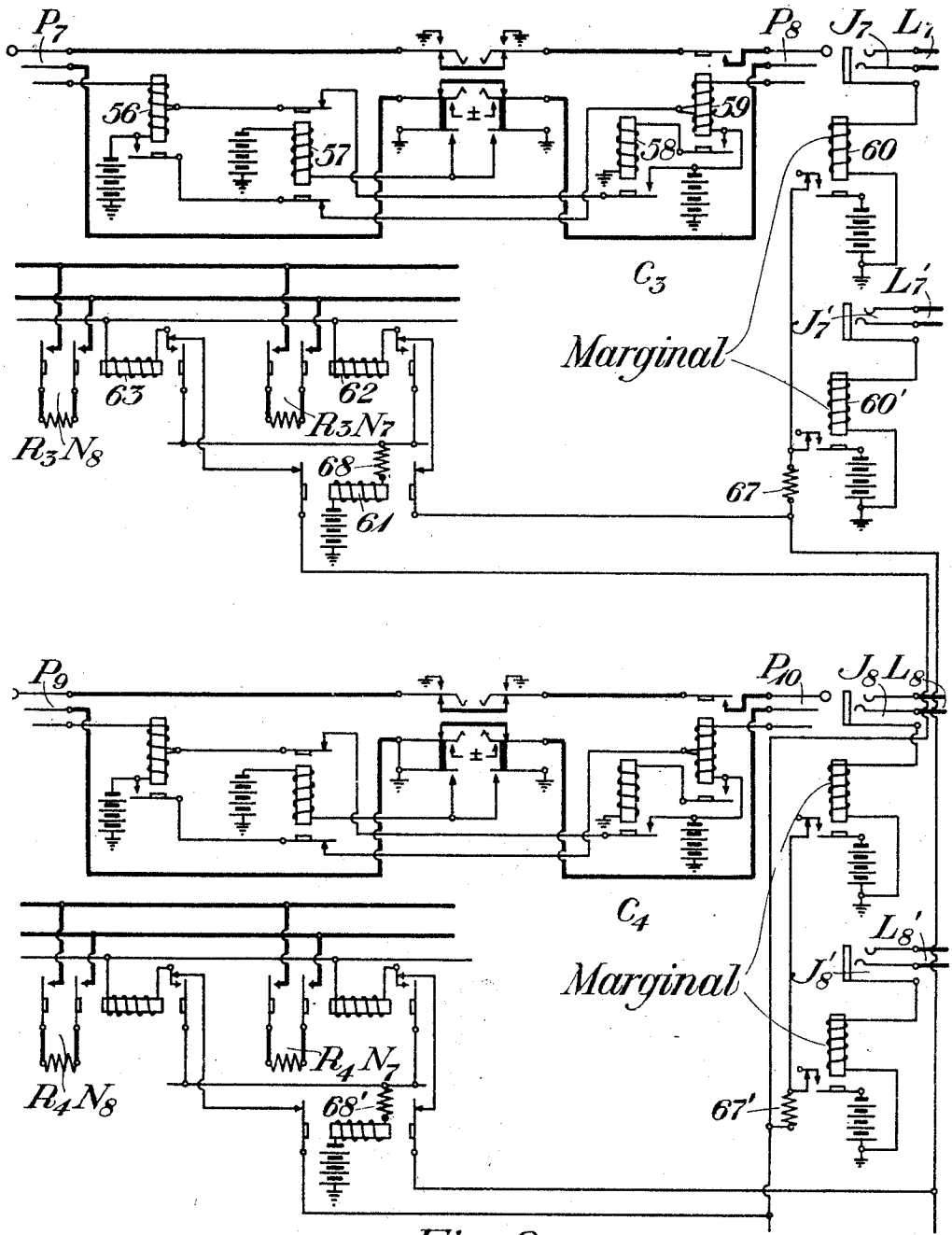

Fig. 6

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UNITED STATES PATENT OFFICE.

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

RELAY-SELECTING CIRCUIT FOR ARTIFICIAL LINES.

1,308,664. Specification of Letters Patent. Patented July 1, 1919.

Application filed June 15, 1917. Serial No. 174,886.

To all whom it may concern:

Be it known that I, CHARLES S. DEMAREST, residing at Flatbush, in the county of Kings and State of New York, have invented certain Improvements in Relay-Selecting Circuits for Artificial Lines, of which the following is a specification.

This invention relates to telephone repeater circuits and more particularly to a means for automatically selecting a suitable artificial line or net-work for balancing a line or trunk with which a repeater is temporarily associated.

It has heretofore been customary when a connection is made between two transmission circuits through a repeater, to provide a balancing artificial line or net-work for each line, said net-works being associated with the repeater. This necessitated either a special repeater circuit having the proper artificial lines or net-works associated therewith for each possible connection between lines of different characteristics, or else a manual switching means whereby the proper artificial line might be temporarily associated with the repeater for each connection. It is proposed by the present invention to provide automatic means, which shall operate, when a repeater is associated with a given transmission circuit, to associate with the repeater an artificial line of a type suitable for balancing such transmission circuit.

The lines or circuits to be connected through a repeater vary considerably with respect to their impedance characteristics and certain lines may require a special net-work for each line while other lines may be grouped into classes or types, the lines of each class having substantially the same impedance characteristics. In the latter case it is only necessary to provide a sufficient number of net-works of each type for handling the maximum traffic over lines of a given class. By this invention it is possible to reduce the number of net-works to the actual traffic requirements by providing for the automatic selection of the net-works. This result is secured by providing in certain cases artificial lines or net-works individual to corresponding lines, but common to some or all of the repeater circuits, and in other cases providing artificial lines or net-works individual to a given repeater circuit but common to a group of lines with each of which a given artificial line is adapted to coöperate.

Means are provided so that when a repeater is associated with a line requiring an individual artificial line or net-work, the particular artificial line associated with that line is connected to the repeater, and when the repeater is associated with one of a group of lines having similar characteristics, an artificial line individual to the repeater and having characteristics suitable for that group of lines is associated with the repeater and through the repeater with the line.

The invention will be more fully understood by reference to the following description taken in connection with the accompanying drawing, Figures 1, 2 and 3 of which, when placed side by side in numerical order constitute a circuit diagram of the invention as applied to a cord circuit repeater, while Figs. 4, 5 and 6 when similarly positioned constitute a circuit diagram of the invention as applied to a so-called four-wire repeater circuit.

Referring to Figs. 1, 2 and 3, a group of lines or trunks L_1, L_1' having a common impedance characteristic are shown terminating in jacks J_1 and J_1'. While for simplicity but two lines are shown of this type it will be understood that any number of lines may have the same impedance characteristic. A second group of lines or trunks L_2, L_2' having a common impedance characteristic which may differ from that of the first group is also shown terminating in jacks J_2, J_2'. Lines or trunks L_3, L_4 are shown as illustrative of another class of lines, each of which has an impedance characteristic peculiar to itself alone and hence requires an individual balancing artificial line or net-work. Said lines are illustrated as terminating in jacks J_3 and J_4, and while only two such lines are illustrated it will be understood that in actual practice any number of such lines may occur.

For interconnecting the lines, cord circuit repeaters R_1 and R_2 are provided, said repeaters terminating in plugs P_1, P_1' and P_2, P_2' respectively, the plugs being adapted to coöperate with the jacks of any of the lines. While for simplicity the repeater elements are illustrated as being of the well known mechanical type it is understood that

vacuum tube or any other type of repeaters may be employed. In practice a sufficient number of repeaters would of course be provided to handle the traffic. Associated with each line of the type of lines J_3 and J_4 is a corresponding balancing artificial line or net-work N_3, N_4, etc., each artificial line being individual to the corresponding line and adapted to be connected to the repeater for balancing purposes when the repeater is used to establish a connection between one of said lines and another line. The particular means for connecting the artificial line to the repeater is illustrated as a combination of relays, the nature of which will be more fully hereinafter described. Lines such as L_1, L_1' and L_2, L_2' do not require an artificial line for each transmission line as all of the lines of same type may be balanced by the same artificial line and it is only necessary to supply a sufficient number of artificial lines to satisfy the traffic requirements of these lines. This may be conveniently accomplished by providing each repeater with artificial lines individual thereto for coöperation with any of the lines of the same type. Accordingly an artificial line or net-work R_1 N_1 is associated with the answering end of the cord circuit repeater R_1 to balance all lines of the type of lines L_1 and L_1', said artificial line being connected to the repeater R_1 whenever a connection is completed over any line of that type and through repeater R_1. The artificial line may be connected to the repeater by a set of relays similar to that already referred to. In a similar manner repeater R_2 is provided with artificial lines R_2 N_1 in all respects similar to artificial line R_1 N_1.

Individual to the calling end of repeater R_1 is an artificial line or net-work R_1 N_2 for balancing all lines of the type of lines L_2 and L_2', a similar artificial line R_2 N_2 being associated with repeater R_2 for the same purpose. These artificial lines are connected to their respective repeaters by means of a combination of relays such as has been already referred to. If it be assumed that lines such as L_1, L_1' are of a different type from lines such as L_2, L_2' and that consequently artificial lines R_1 N_1 and R_2 N_1 are of a different type from artificial ines R_1 N_2 and R_2 N_2, or if it be assumed that there may be still other groups of lines capable of being balanced by common artificial lines of still different types, each end of each repeater should have individual thereto an artificial line corresponding to each group of lines. The additional artificial lines for different groups of lines have not been illustrated as the method of associating them with the repeaters is identical with that illustrated.

The relay apparatus whereby the artificial lines are associated with the repeaters comprises a set of connecting relays individual to each line, there being as many relays for each line as there are repeaters. When any line is extended through a repeater, a selecting circuit is established through the relay individual to that line and corresponding to the repeater employed, so that the relay is energized to connect to the repeater an artificial line suitable for balancing such transmission line. The relay is locked up independent of the selecting circuit and completes a circuit for the control of other relays which function to disconnect all of the connecting relays individual to the line in question from the selecting circuit, so that the selecting circuit is free for other selections and so that no other repeater can be connected to the artificial line which is now in use.

With this general description in mind the circuits will be fully understood from a description of the operation. Assuming that it is desired to interconnect lines L_1 and L_4 through repeater R_1, plug P_1 is inserted in jack J_1 and plug P_1' is inserted in jack J_4.

A circuit is thereby completed over the sleeve contacts of plug P_1 and jack J_1 from battery, through the windings of relays 1 and 2 to ground. Relay 1 is energized but relay 2 is marginal and does not receive sufficient current to energize it with its winding in series with the high resistance of relay 1. A similar circuit is closed over the sleeve contacts of plug P_1' and jack J_4 through the windings of relays 3 and 4, relay 4 being marginal so that it is not energized in series with the high resistance of relay 3. The control key K_1 is then operated, closing at its upper contact a low resistance path from battery, in parallel with relay 3, so that relay 4 receives sufficient current to energize its winding. Relay 4 closes a selecting circuit from ground, contact of relay 4, winding of connecting relay 5, lower back contact of said relay, contact of relay 7, resistance 9, right hand back contact and winding of relay 10, lower contact of key K_1, contact of relay 3 to battery. Relays 5 and 10 are energized, a locking circuit being established for relay 5 from ground, contact of relay 4, winding and front lower contact of relay 5, resistance 11, and winding of relay 12 to battery. Relay 12 is energized over this circuit and completes a circuit for relays 7, 8 etc., which operate to disconnect the initial circuits of connecting relays 5, 6, etc., from the selecting circuit to prevent the selection of artificial line N_4 by any other repeater. Net-work N_4 is now connected to the answering end of repeater R_1 over the upper contacts of relay 5 which remains locked up so long as relay 4 is energized.

The energization of relay 10 over the circuit above traced results in the disconnection of the selecting circuit from repeater

R_1 at the right hand contact of said relay, the relay being locked up over a circuit from ground, front right hand contact and winding of said relay, lower contact of key K_1, contact of relay 3 to battery.

The resistance 9 is of such value that should the controlling keys of two repeaters be operated at the same instant neither connecting relay will operate. For instance, if at the same time that key K_1 was operated, key K_2 of repeater R_2 had been operated, the plug P′ of said repeater being at the same time associated with jack J_2', the following circuits would be simultaneously established.

From battery, contact of relay 3, lower contact of key K_1, winding and back contact of relay 10, resistance 9 to point 13 where the circuit divides, one branch continuing over contact of relay 7, lower back contact and winding of relay 5 and over contact of relay 4 to ground, the other branch continuing from point 13 over contact of relay 7′, lower back contact and winding of relay 5′ and over contact of relay 4′ (energized when key K_2 was closed) to ground. A second circuit may be traced from battery, contact of relay 3′, lower contact of key K_2, winding and right hand back contact of relay 10′, resistance 9′ to point 13′ where the circuit divides, one branch continuing over contact of relay 8, lower back contact and winding of relay 6 and over contact of relay 4 to ground, while the other branch extends over contact of relay 8′, lower back contact and winding of relay 6′ and over contact of relay 4′ to ground. It is thus seen that circuits are established for relays 5, 6, 5′ and 6′, whereby artificial line N_4 would be connected to both repeaters R_1 and R_2, while artificial line R_1 N_2 would be also connected to repeater R_1 and artificial line R_2 N_2 would be connected to repeater R_2, were it not for the fact that the resistances 9 and 9′ are of values sufficient to prevent the connecting relays from energizing over the parallel circuits above traced, a false operation being thus avoided. To still further avoid a false selection in case two connecting relays such as 5 and 6 for instance should happen to be energized over the parallel circuits just described, resistance 11 is provided of such value that two connecting relays in parallel will not lock up in series with said resistance. In this manner false selection is avoided and the operator will have to restore the key and again operate it in order to select a network.

Returning now to relay 10 which it will be remembered was energized and locked up said relay upon being energized establishes a circuit from ground, left hand contact of said relay, winding of relay 14 to battery thus energizing relay 14. Relay 14 at its right hand contact connects battery through a resistance directly to the sleeve of plug P_1 in parallel with the winding of relay 1 so that marginal relay 2 now receives sufficient current to energize its winding. Upon the energization of relay 2, a circuit is closed from ground, contact of relay 2, winding and lower back contact of relay 15, contact of relay 17, resistance 19, back contact and winding of relay 20, left hand contact of relay 14 and contact of relay 1 to battery. Relays 15 and 20 are operated over this circuit, relay 15 opening at its lower contact the connection between said relay and the selecting circuit and locking itself over a circuit from ground, contact of relay 2, winding and lower front contact of relay 15, resistance 21 and winding of relay 22 to battery. Relay 22 is energized over this circuit and closes a circuit for relays 17, 18, etc., which operate to open the original energizing circuits of the connecting relays 15, 16, etc., associated with line L_1 so that no other repeater can operate any of these relays. Relay 20 upon being energized operates to disconnect the selecting circuit from repeater R_1 and locks itself by a circuit from ground, front contact and winding of said relay, left hand contact of relay 14, contact of relay 1 to battery.

Upon the energization of relay 15, artificial line R_1 N_1 is connected over the upper contacts of said relay to the answering end of the repeater R_1. Lines L_1 and L_4 are now interconnected through repeater R_1, the line L_1 being balanced by artificial line R_1 N_1 and line L_4 being balanced by artificial line N_4. Had the plug P_1 of repeater R_1 been inserted in jack J_1' instead of J_1, the artificial line R_1 N_1 would have been connected to the repeater to balance line L_1' by connecting relay 15′ instead of by relay 15. Had the plug P_1' of repeater R_1 been inserted in jack J_2' of line L_2', relay 5′ would have operated to connect artificial line R_1 N_2 to the repeater. Had the connection between lines L_1 and L_4 been made through repeater R_2 instead of R_1, relay 6 would have operated to connect artificial line N_4 to the repeater to balance line L_4, while relay 16 would have operated to connect artificial line R_2 N_1 to the repeater to balance line L_1. The artificial line is disconnected as soon as the control key is released or the plug of the repeater is withdrawn from the line jack. Withdrawing plug P_1 from jack J_1 for instance, deënergizes relay 2, and the locking circuit of connecting relay 15 and relay 22 is thereby broken, restoring the relays 17, 18, etc., to normal, and disconnecting artificial line R_1 N_1 from repeater R_1.

It will be noted that the selection of an artificial line for the answering end of the repeater cannot take place until an artificial

line has been selected for the calling end, since the selection for the answering end is instituted by the energization of relay 14 whose circuit is closed by relay 10 which is energized simultaneously with the completion of the selecting circuit for the calling end of the repeater. The purpose of this construction is to prevent a false operation such as has already been described in connection with simultaneous operation of the controlling keys of two repeaters. This will be clear if it be assumed that plug P_1' of repeater R_1 is inserted in jack J_4 and plug P_1 thereof inserted in jack J_2'. It will be seen at once if the selecting circuits for both ends of the repeater were closed simultaneously, parallel circuits would be simultaneously completed for two connecting relays individual to line L_4 and corresponding to each end of the repeater, as well as for similar relays individual to line L_2'. These relays would not be energized over parallel circuits and no selection could take place. This difficulty is avoided by delaying the selection for the answering end of the repeater as above described.

The organization just described is an embodiment of the invention as applied to cord circuit repeaters. Figs. 4, 5 and 6 constitute a diagram of the circuits whereby the invention may be utilized in connection with a four wire repeater circuit. Referring to said figures, reference characters A and B designate generally the apparatus located at two stations which may be a considerable distance apart. Each channel of communication between said stations comprises a four wire transmission circuit terminating at each end in apparatus for associating a two wire line or trunk with the four wire circuit. In the drawings two four wire transmission or repeater circuits are shown, said circuits being designated R_3 and R_4, although it will be understood that as many such channels of communication will be provided as the traffic requires. At station A the four wire circuit R_3 is shown as terminating in a jack J_9 whereby any two wire line or trunk coming into said station may be connected to the four wire circuit. Similarly at station B said four wire circuit terminates in a jack J_{10} for connections with any of the lines or trunks extending from said stations. Incoming signaling currents from a line or trunk terminating at station A are led over the terminals of jack J_9 to the input circuit 30 of a repeater element 31. This repeater element as well as the other repeater elements shown in Fig. 5 is herein illustrated for simplicity as a mechanical repeater element, but it will be understood that an element of the vacuum tube or other well known type may be used in practice if desired. The amplified currents in the output circuit 32 of repeater 31 are transmitted through an induction coil 33 to a two wire trunk R_3 L′ leading to station B and over which they are conducted to the input circuit 34 of another repeater 35, whose output circuit 36 terminates in the primary of a three limb induction coil 37. This coil is so arranged that the energy from circuit 36 divides, one half being transmitted over the line terminals of jack J_{10} to an outgoing line at station B and the other half being transmitted to a balancing artificial line or net-work. The input circuit 38 of another repeater 39 is connected to neutral points with respect to the energy transmitted to induction coil 37 and hence is substantially unaffected thereby. On the other hand incoming signals from the line or trunk terminating at station B are transmitted over the line terminals of jack J_{10} to the input circuit 38 of repeater 39, the amplified currents in output circuit 40 being transmitted through an induction coil 41 to a two wire trunk R_3 L leading back to station A and over which the currents are conducted to the input circuit 42 of a repeater 43, the output circuit 44 of which terminates in the primary of a three limb induction coil 45. This coil is similar to induction coil 37 and the energy from output circuit 44 therefore divides between the line or trunk associated with jack J_9 and the balancing artificial line or net-work, without affecting the input circuit 30 of repeater 31.

It will be seen that transmission in one direction always takes place over the two wire trunk R_3 L and in the other over two wire trunk R_3 L′, and that by means of suitably proportioned balancing artificial lines the tendency to sing over the pair of two wire trunks constituting the four wire circuit may be substantially eliminated. The system has the additional advantage, moreover, that the repeaters may be adjusted so that the amplification in any one of the two wire trunks such as R_3 L′ for example may be made at least equal to the attenuation of such trunk, without causing any tendency to sing. In other words currents applied to the trunk at station A may arrive at station B without any attenuation, thus bringing stations A and B together electrically so far as transmission is concerned. At the same time no tendency to sing would result as any component of the current arriving at station B, which might be transmitted back to station A due to improper balance, would in any case arrive at such station with no greater amplitude than that with which it started. The condition for singing requires that the current flowing back over the return circuit to the input circuit of the repeater must be equal to or greater than that which was originally applied to the input circuit. Inasmuch as the component transmitted over the return circuit will always be less

than that arriving at the receiving station because of the balancing of the circuits, the repeaters may not only be adjusted so as to neutralize the attenuation of the trunk but so that the current will arrive at the distant end of the trunk augmented in value without any consequent singing as a result, it being merely necessary to keep the amplification below the point at which the back flowing component of the current applied to the input of a repeater at the sending point, will arrive at said input circuit with a value equal to or greater than the current originally applied.

It will be understood that if a high amplification is not necessary the second set of repeaters 35 and 43 may be omitted, or if greater amplification is desired additional repeaters may be inserted in the trunks R_3 L and R_3 L' at various points between stations A and B. The four wire repeater R_4 is in all respects similar to repeater R, and need not be described in detail.

The two wire lines and trunks terminating at stations A and B may be grouped in accordance with their impedance characteristics, those having the same characteristics being included in the same group and being adapted to be balanced by the same artificial line or net-work. Thus at station A lines L_5 and L_5' represent a group of lines having the same impedance characteristic, said lines terminating in jacks J_5 and J_5'. Any number of lines may be included in this group. Lines L_6 and L_6' are representative of a second group having a different common impedance characteristic, said lines terminating in jacks J_6 and J_6'. At station B lines L_7 and L_7' are representative of a group of lines having the same impedance, said lines terminating in jacks J_7 and J_7', while lines L_8 and L_8' are illustrative of another group of lines having a different common impedance characteristic, said lines terminating in jacks J_8 and J_8'.

Cord circuits C_1 and C_2 are provided at station A to connect any of the incoming lines to the jacks leading to outgoing four wire circuits. Cord circuit C_1 terminates in plugs P_3 and P_4 at the incoming and outgoing ends respectively, while cord circuit C_2 similarly terminates in plugs P_5 and P_6. At station B cord circuit C_3 terminating in plugs P_7 and P_8, and cord circuit C_4 terminating in plugs P_9 and P_{10} are provided to interconnect the outgoing lines and the incoming four wire circuits. As many cord circuits may be provided at each station as the traffic requires.

Associated with repeater R_3 at station A is an artificial line R_3 N_5 adapted to balance any of the lines of the group to which lines L_5 and L_5' belong, and a second artificial line R_3 N_6 to balance any of the lines of the group to which lines L_6 and L_6' belong. In order to connect the artificial lines to the repeater a set of connecting relays individual to the repeater are provided, there being one connecting relay corresponding to each group of lines. When any connecting relay is operated by a line of one group to connect the artificial line corresponding to that group to the repeater, the relay locks up and all of the connecting relays are disconnected from the selecting circuit to prevent the connection of any other artificial line to the repeater.

In a similar manner repeater R_4 has associated therewith at station A artificial lines R_4 N_5 and R_4 N_6 for balancing a line of either group. At station B artificial lines R_3 N_7 and R_3 N_8 are associated with four wire repeater R_3 and artificial lines R_4 N_7 and R_4 N_8 are associated with four wire repeater R_4 to balance any line of either group outgoing from station B. The artificial lines are connected to the repeaters by connecting relay arrangements similar to those already described.

Assuming it is desired to connect line L_5 at station A through four wire circuit R_3 to line L_7 at station B, the operator at station A takes up the plug P_3 of an idle cord circuit, for example cord circuit C_1, and inserts it into jack J_5 of line L_5, and at the same time inserts plug P_4 thereof into jack J_9 of four wire circuit R_3. Upon inserting plug P_3 into jack J_5 a circuit is closed from ground, winding of relay 46, sleeve contact of jack J_5 and plug P_3, and both windings of relay 47 to battery, thereby energizing relay 47. Relay 46 is marginal however and does not pull up its armature in response to current through the entire winding of relay 47. Upon inserting plug P_4 in jack J_9 a circuit is closed from ground, through the winding of relay 48, sleeve contacts of jack J_9 and plug P_4 and through both windings of relay 49 to battery. Relay 49 is energized but relay 48 is marginal and does not operate over this circuit. Relay 47 upon being energized closes a circuit over its lower contact for relay 50 which short circuits the lower winding of relay 49 and closes an energizing circuit for relay 48 from battery, contact of relay 50, upper normal contact of relay 51, upper winding of relay 49, sleeve contacts of plug and jack, winding of relay 48 to ground. Relay 48 is now energized. When relay 49 was operated, it in turn short-circuited the lower winding of relay 47 and closed an energizing circuit for relay 46 from battery, contact of relay 49, normal lower contact of relay 51, upper winding of relay 47, sleeve contacts of the plug and jack, winding of relay 46 to ground. Both relays 46 and 48 are now energized and as the selecting circuit is under the joint control of these two relays it will be seen that selection cannot

take place until the cord circuit has been connected to both the line and the four wire circuit.

When both relays 46 and 48 have been energized a momentary selecting circuit, is closed from battery, contact of relay 46, resistance 65, normal left hand contact of relay 52, normal left hand contact and through winding of relay 53, over contacts of relay 48 to ground. Relay 53 is energized and closes a locking circuit from ground, contact of relay 48, winding and left hand front contact of relay 53, resistance 66, winding of relay 52 to battery. Relay 52 is energized over this circuit and disconnects the windings of connecting relays 53 and 54 from the selecting circuit. Relay 53 which is now locked up, at its right hand contacts connects artificial line R_3 N_5 to repeater R_3 to balance line L_5. Had the plug P_3 been inserted in the jack J_5' of line L_5', the same result would have been accomplished, the selecting circuit being closed over the contact of relay 46′ instead of relay 46. The resistances 65 and 66 are for the purpose of preventing a false operation as described in connection with Figs. 1, 2 and 3.

Upon receiving the signal indicating the connection desired, (the signaling means is not illustrated as it forms no part of the invention), the operator at station B takes up the plug P_7 of an idle cord circuit, say C_3, and inserts said plug into jack J_{10} of the four wire circuit and plug P_8 into jack J_7 of line L_7. Circuits are now closed to energize relays 56 and 59, the former operating to short circuit the lower winding of the latter so that marginal relay 60 is energized, while relay 59 operates to close the circuit of relay 58, which in turn short-circuits the lower winding of relay 56 so that marginal relay 55 is energized. A momentary selecting circuit is now completed from battery, contact of relay 60, resistance 67, normal right hand contact of relay 61, right hand back contact and winding of relay 62, contact of relay 55 to ground. Relay 62 is now energized and locks itself through resistance 68 and the winding of relay 61 which operates to disconnect relays 62, 63, etc., from the selecting circuit. Artificial line R_3 N_7 is now connected over the left hand contacts of relay 62 to the repeater R_3 to balance line L_7.

Had the connection been made from a line of the second group at station A by inserting plug P_3 in jack J_6 of line L_6 for instance, relay 63 would have been energized and a momentary selecting circuit would have been closed from battery, contact of relay 63, resistance 65′, back right hand contact of relay 52, front left hand contact and winding of relay 54, contact of relay 48 to ground, energizing relay 54 so that artificial line R_3 N_6 is connected to the repeater R_3. In case a connection is made through the four wire circuit R_4, the artificial line R_4 N_5 would be connected to the repeater in a similar manner if the repeater is connected to a line such as L_5 for instance, while artificial line R_4 N_6 will be connected to the repeater if the latter is connected to a line such as L_6. Similarly at station B the artificial line R_4 N_7 or R_4 N_8 will be connected to the repeater R_4 depending upon whether connection is made to a line of the group to which line L_7 belongs, or to a line of the group to which line L_8 belongs.

When the connection is taken down the apparatus is restored to normal as follows: Plugs P_3 and P_4 of cord circuit C_1 are withdrawn from the jacks J_5 and J_9, marginal relays 46 and 48 being thereby deënergized. The locking circuit of the connecting relay 53 is opened at the contact of relay 48 and the connecting relay as well as relay 52 is restored to normal, thereby disconnecting the artificial line. The artificial line at station B is of course disconnected in a similar manner when the plugs of the cord circuit C_3 are withdrawn from the jacks.

By means of the arrangements above described it will be seen that simple and efficient means for the automatic selection of an artificial line to balance a transmission line has been provided, and while the invention has been disclosed as embodied in certain forms which are considered desirable it will be understood that it may be embodied in many widely different organizations without departing from the spirit of the appended claims.

What is claimed is:

1. The combination with a repeater, of a plurality of transmission lines capable of being balanced by the same artificial line, a plurality of balancing artificial lines and means comprising selecting relays for associating one of said artificial lines with the repeater and one of said transmission lines.

2. In combination, a plurality of transmission lines capable of being balanced by the same artificial line, a plurality of balancing artificial lines less in number than said transmission lines each adapted to balance any of said transmission lines, and means comprising selecting relays for associating one of said artificial lines with one of said transmission lines.

3. In combination, a transmission line, a balancing artificial line for said transmission line, and means comprising selecting relays for associating said artificial line with said transmission line.

4. In combination, a transmission line, a plurality of repeaters, a balancing artificial line for said transmission line, and means comprising selecting relays and responsive to the connection of any one of said repeat-

ers with said transmission line to associate the artificial line with the transmission line and said repeater.

5. In combination, a plurality of transmission lines divided into groups, the lines in certain of said groups having common characteristics, the lines in other of said groups having individual characteristics, artificial lines individual to the transmission lines having individual characteristics, other artificial lines common to the lines of a group having the same characteristics, and means comprising selecting relays for associating with any transmission line an artificial line adapted to balance the same.

6. In combination, a plurality of transmission lines divided into groups, the lines in certain of said groups having common characteristics, the lines in other of said groups having individual characteristics, repeaters for interconnecting the lines, artificial lines individual to each of the lines having individual characteristics, artificial lines individual to the repeaters for balancing any line of a group having common characteristics, and means comprising selecting relays for associating with any transmission line an artificial line adapted to balance the same.

7. In combination, a plurality of transmission lines, a plurality of repeaters for interconnecting the lines, artificial lines for balancing the transmission lines, and means for associating an artificial line with a transmission line, said means comprising sets of connecting relays individual to each transmission line and each set comprising relays individual to each repeater.

8. In combination, a plurality of transmission lines, a plurality of repeaters for interconnecting the lines, artificial lines for balancing the transmission lines, a set of connecting relays individual to each line, the relays of each set being individual to the several repeaters, and means controlled by each relay of a set to connect to the repeater to which the relay is individual, an artificial line to balance the transmission line to which the relay set is individual.

9. In combination, a plurality of transmission lines, a plurality of repeaters for interconnecting the lines, artificial lines for balancing the transmission lines, a plurality of connecting relays for associating an artificial line with a transmission line, the circuit of each relay being under the joint control of a transmission line and a repeater.

10. In combination, a plurality of transmission lines, a plurality of repeaters for interconnecting the lines, artificial lines for balancing the transmission lines, a plurality of connecting relays for associating an artificial line with a transmission line, controlling relays for each line and for each repeater, the controlling relays of a line and a repeater being energized upon the association of the repeater with the line, and a circuit for each connecting relay under the joint control of the controlling relay of a line and the controlling relay of a repeater.

11. In combination, a plurality of transmission lines, a plurality of repeaters for interconnecting the lines, artificial lines for balancing the transmission lines, means comprising selecting relays to associate an artificial line with the incoming end of a repeater to balance a transmission line associated with that end of the repeater, means comprising selecting relays to associate an artificial line with the outgoing end of a repeater to balance a transmission line associated with the latter end of the repeater, and means to delay the selection of artificial lines for one end of the repeater until after the selection for the other end has taken place.

12. In combination, a plurality of transmission lines, a plurality of repeaters for interconnecting the lines, controlling means associated with each repeater, artificial lines for balancing the transmission lines, means responsive to the controlling means individual to each repeater for selecting an artificial line for a transmission line associated with said repeater, said means comprising selecting relays, and means to prevent false operation of the selecting relays when the controlling means of more than one repeater are simultaneously actuated.

In testimony whereof, I have signed my name to this specification this seventh day of June, 1917.

CHARLES S. DEMAREST.