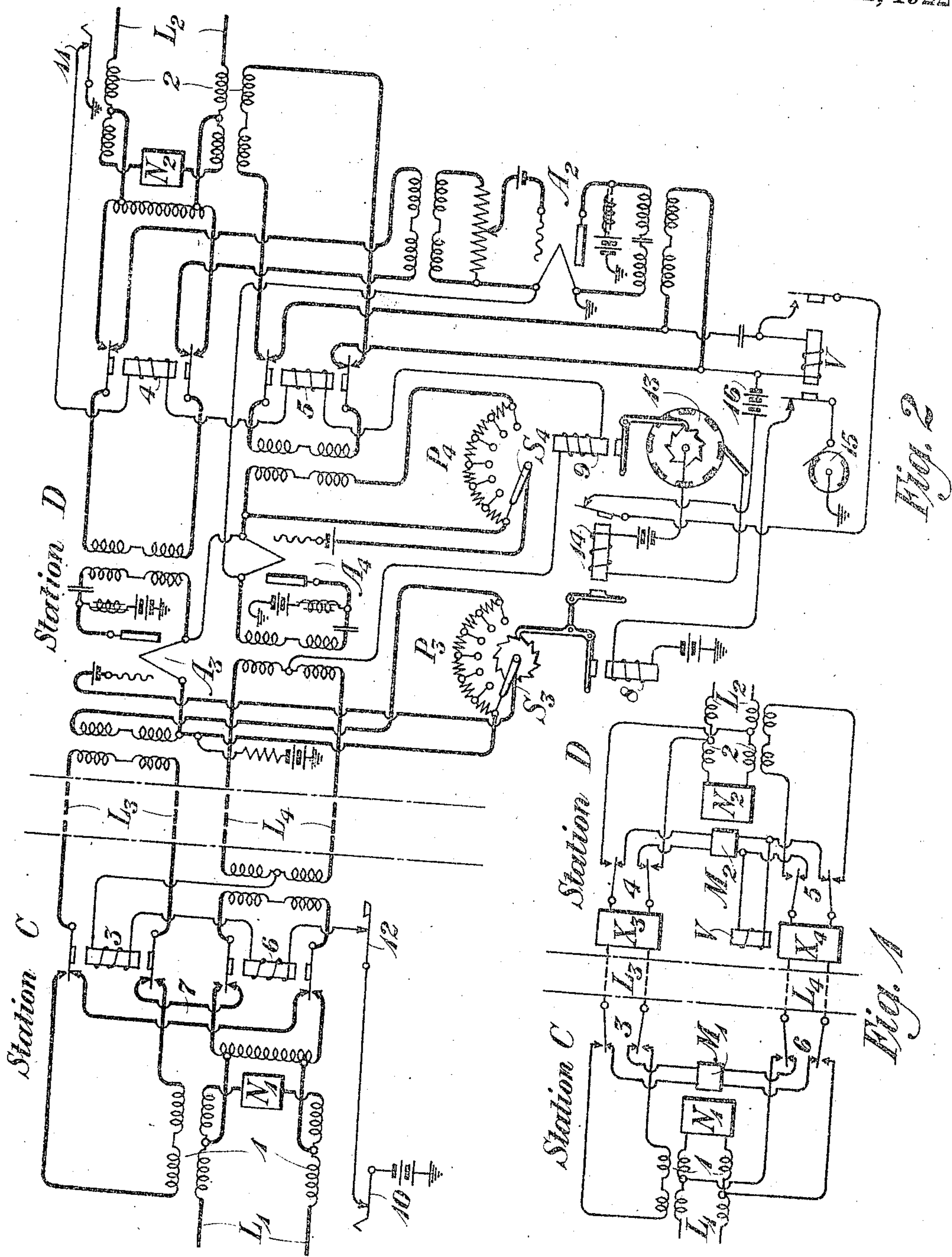


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 MEANS FOR AND METHOD OF REGULATING THE TRANSMISSION OVER ELECTRIC CIRCUITS;
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MEANS FOR AND METHOD OF REGULATING THE TRANSMISSION OVER ELECTRIC CIRCUITS.

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To all whom it may concern:

Be it known that I, ALVA B. CLARK, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Means for and Methods of Regulating the Transmission over Electric Circuits, 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 circuits, although it is in general applicable to transmission circuits of any kind.

The principal object of the invention is to provide suitable methods and means for maintaining substantially constant the transmission equivalent of a circuit regardless of variations in the conditions affecting the electrical characteristics of the circuit. Other and further objects will, however, be clear from the description of the invention hereinafter given.

In general, the transmission equivalent of a circuit varies, due to a number of different causes. If the transmission circuit be of the four-wire type, in which a pair of separate transmission lines are employed for transmitting in opposite directions, these causes may be divided into two classes: The first class comprises causes which affect both sides of the circuit, or in other words, both transmission lines, in the same manner. Among these causes may be enumerated variations in the resistance of the conductors, loading coils, etc., variations in capacity, inductance, or other electrical characteristics of the cable, and variations in the potential of repeater batteries common to repeaters in both sides of the circuit. The second class comprises causes which affect the two sides differently, such as variations in the structure of repeater bulbs where vacuum tube repeaters are employed, variations in the potentials of grid batteries, or accidental variations due to the resistance of bad joints, leakage due to poor insulation, etc.

In the case of transmission circuits in which only one transmission line is used for transmission in the two directions, the factor of variation with respect to the two sides of the circuit will be absent, but some or all of the above causes may contribute to produce variations in the transmission

equivalent of the circuit, thereby rendering it highly desirable that some provision be made for overcoming the effect of these variations.

The present invention contemplates eliminating these difficulties by varying some adjustable element of the transmission circuit to compensate for the variations introduced into the circuit. In general a number of methods may be employed in carrying out the objects of this invention. For example, the effects due to some one cause, such as temperature variations, may be compensated for by observing the changes produced in one circuit of a cable and then varying in accordance with such changes, similar elements of a number of circuits which are affected in a like manner. In the case of a four-wire circuit, where it is desired to take into account variations which do not affect both sides of the circuit alike, adjustment may be made for each side of the four-wire circuit separately to compensate for all causes of the variation in either side. Where less precision is required, effects due to all possible variations in the two sides of the four-wire circuit may be compensated for by simultaneously varying like elements in the two sides of the circuit on the assumption that the two sides vary alike.

These methods may be carried out either manually or automatically and by making adjustments either constantly with variations in the circuit, or at intervals of suitable frequency. For purposes of illustration, apparatus is disclosed for automatically carrying out the last method above mentioned, but it will be understood that manual apparatus may be employed if desired.

The objects of the invention are secured as herein disclosed by disconnecting the ends of the two transmission lines, comprising a four-wire circuit, from their terminating arrangements, and interconnecting the ends through adjustable transmission devices capable of introducing transmission losses or gains, which together are adjusted to have a transmission equivalent double and opposite in sign to that to which the sides of the four-wire circuit, exclusive of the terminals, are to be adjusted. The path thus formed will sing when the amplification

therein exceeds the loss, and the circuit will have the proper transmission equivalent when it is adjusted to a critical point at which singing just begins or just ceases.

5 Accordingly, by arbitrarily bringing the equivalent of the path well below the singing point, and then gradually adjusting the circuit until singing just begins, or by
10 raising the equivalent well above the initial singing point and gradually adjusting the circuit until singing just ceases, the circuit will be set for the proper transmission equivalent. This may be accomplished by ad-
15 justing transmission elements in the transmission lines themselves.

Where the former method is employed, the amplification in the closed path may be reduced until it is less than the total loss, preferably by decreasing the amplification
20 of one-way repeaters in the two transmission lines of the four-wire circuit. By then gradually increasing the amplification of the similar amplifiers in the two transmission lines until singing just commences,
25 which occurs when the total amplification is approximately equal to the total loss, the four-wire circuit will be set for the desired transmission equivalent. In order to perform these functions automatically, the cir-
30 cuit may be so arranged that when the two ends of the four-wire circuit are interconnected, an automatic switch controlling the setting of the potentiometers which determine the amplification of the repeaters, will
35 be restored to a normal condition in which the potentiometers are set for the least possible amplification. The switch then begins to advance, gradually adjusting the potentiometers, and thereby increasing the ampli-
40 fication until a point is reached at which singing commences. An alternating current relay, responsive to the singing oscillations, may then be arranged to stop the motion of the switch, so that the circuit remains ad-
45 justed at the critical point at which singing just commences.

The invention may now be more fully understood from the following description when read in connection with the accom-
50 panying drawing, Figure 1 of which is a schematic diagram of an arrangement in which the invention may be embodied, while Figure 2 is a circuit diagram showing an automatic apparatus for carrying out the
55 invention, as applied to a four-wire circuit.

Referring to Figure 1, a four-wire circuit is shown interconnecting two terminal stations C and D, said four-wire circuit comprising
60 a pair of transmission lines L_3 and L_4 for transmitting in opposite directions. It will be understood that these transmission lines may include one way repeaters (not shown) for securing the desired transmission over the circuit. At the terminal station the
65 four-wire circuit may be associated by means

of the usual three-winding transformers 1 and 2, with terminating two-wire lines L_1 and L_2 , said two-wire lines being balanced by suitable artificial lines N_1 and N_2 . When
70 it is desired to adjust the transmission of the four-wire circuit the ends of the lines L_3 and L_4 may be disconnected from their terminal arrangements by means of relays 3, 4, 5 and 6, only the contacts of which are shown in
75 Figure 1. By means of these relays the ends of the lines L_3 and L_4 may be interconnected through the adjustable transmission devices M_1 and M_2 indicated schematically. These devices may be of any suitable
80 character and should be so designed as to have a total transmission equivalent whose value is double and opposite in sign to, that to which it is desired the sides of the four-
85 wire circuit exclusive of the terminal apparatus shall be adjusted. In other words, if it is desired to arrange the four-wire circuit so that each of its two sides will give a cer-
90 tain gain in transmission, the devices M_1 and M_2 should together represent a transmission loss equal to twice the desired gain. On the other hand, if it is desired that there shall be
95 a certain transmission loss in each of the two sides, the devices M_1 and M_2 should comprise amplifiers, or other means whereby a total transmission gain equal to twice the
100 desired loss may be produced. In order to simplify the arrangement, the devices M_1 and M_2 may be combined at one station as shown in Figure 2 so that at the other sta-
105 tion the ends of the transmission lines L_3 and L_4 are directly connected. In order to adjust the transmission equivalent of the four-wire circuit, transmission varying de-
110 vices X_3 and X_4 which will give either losses or gains may be provided in lines L_3 and L_4 respectively. These devices should first be
115 set so as to make the amplification less than the loss in the closed path through M_1 , M_2 , L_3 , L_4 , X_3 and X_4 , so that singing does not take place. The transmission devices X_3
120 and X_4 may then be adjusted either manually or automatically, until the amplification is equal to or but slightly greater than the loss, whereupon singing oscillations are
125 set up in the circuit. The oscillations actuate the device V to indicate to the operator that the proper adjustment has been reached in the case of a manual adjustment, or to au-
130 tomatically stop further adjustment where the operation is mechanical. When the condition of adjustment above referred to has been reached, the total transmission equivalent of the complete loop is substantially
135 zero, so that the actual transmission equivalent of that portion of the loop comprising the lines L_3 and L_4 and the transmission
140 varying devices X_3 and X_4 is substantially equal to, but opposite in sign to, that of the devices M_1 and M_2 . Assuming that the de-
145 vices M_1 and M_2 have been properly set, the

four-wire circuit will now have the desired transmission equivalent.

Turning now to Figure 2, which shows in more detail an arrangement corresponding to that illustrated schematically in Figure 1, it will be seen that amplifiers A_3 and A_4 are inserted in the line L_3 and L_4 respectively, and correspond to the devices X_3 and X_4 respectively of Figure 1. In order to control the amplification of these amplifiers, potentiometers P_3 and P_4 are provided, the setting of said potentiometers being determined by an automatic switch, including wipers S_3 and S_4 . Relays 3, 4, 5 and 6 are shown for the purpose of disconnecting the transmission lines L_3 and L_4 from the terminating arrangement at stations C and D, and for interconnecting the ends of said lines in order to regulate the transmission thereof. At station C the lines L_3 and L_4 may be directly connected over path 7. At station D the ends of these lines are interconnected through an adjustable transmission device comprising an amplifier A_2 corresponding to the device M_2 of Figure 1. A stepping magnet 8 is provided to control the advancement of the switch including wipers S_3 and S_4 . Bridged across the path including the amplifier A_2 is an alternating current relay V which responds to singing over the four-wire circuit to open the circuit of the stepping magnet and bring the switch to rest. The relays 3, 4, 5 and 6, as well as relay 9, are included serially in a simplex circuit passing over the two sides of the line L_1 . Any other suitable circuit connecting the terminals of the four-wire circuit may, of course, be employed. This circuit is normally closed but is opened by means of switches 10 and 11 which may be operated in a manner well understood in the art when connections are completed over the two-wire lines L_1 and L_2 to the four-wire circuit, thereby de-energizing relay 9, and relays 3, 4, 5 and 6. Relays 3, 4, 5 and 6 upon being de-energized, connect the four-wire circuit to the terminal arrangement. The simplex circuit controlling these relays may also be opened by means of a switch 12 which may be either hand operated, or may be operated at regular intervals by means of a suitable timing arrangement. When the simplex circuit is again closed upon the taking down of the connection over lines L_1 and L_2 , or by the closing of switch 12, the relays 3, 4, 5 and 6 again disconnect the four-wire circuit from the terminal arrangement and interconnect the ends of the lines L_3 and L_4 . The relay 9 at the same time advances a commutator arrangement 13 one step so that the brush thereof passes over a live segment of the commutator and sends a momentary impulse through the release magnet 14 of the potentiometer controlling switch to restore said switch to its normal position, in

which position the potentiometers are set for the lowest degree of amplification. The release magnet 14 also opens the locking circuit of the alternating current relay V which is normally locked up, thereby permitting the stepping magnet 8 to advance the switch until singing just begins. The alternating current relay V responds to the singing oscillations and brings the switch to rest, at the same time closing a locking circuit for its own winding through a battery 16.

Assuming that the amplifier A_2 has been properly adjusted, as explained, upon completing a connection over lines L_1 and L_2 , the switches 10 and 11 will be opened, thereby breaking the normally closed circuit through relays 3, 4, 5, 6 and 9. This circuit may be traced from battery, over switch 10, switch 12, through the windings of relays 6 and 3, thence in parallel over the two conductors of the transmission line L_4 , through the windings of relays 9, 5 and 4, and over switch 11 to ground. Relays 3, 4, 5 and 6 release their armatures so that the ends of the transmission lines L_3 and L_4 are connected through the transformers 1 and 2 to the terminating two-wire lines, and conversation may now take place over the four-wire circuit. The release of magnet 9 permits its armature to retract and engage a new tooth of the commutator arrangement 13, but no circuit change results therefrom.

When the connection over lines L_1 and L_2 is taken down, switches 10 and 11 are again closed to complete the simplex circuit already traced through relays 3, 4, 5 and 6, and through magnet 9. Relays 3, 4, 5 and 6 disconnect the transmission lines L_3 and L_4 from the terminal arrangements and interconnect the ends of said lines through the amplifier A_2 . The magnet 9 is energized at the same time, and in attracting its armature advances the commutator arrangement 13, but no circuit change results therefrom. commutator passes over a live segment thereof and again rests upon an insulating segment. A momentary impulse of current is thereby caused to flow through the release magnet 14, which withdraws the pawl carried by the armature of step magnet 8 from the ratchet wheel of the switch S_3 , S_4 , permitting the switch to be restored to its normal condition, as indicated in the diagram. The release magnet 14 also opens the locking circuit of the alternating current relay V which may be traced from the battery 16 through the winding and over the right hand front contact of said relay, and over the back contact of release magnet 14 back to battery. The relay V is thereby de-energized and at its left hand back contact completes a circuit from ground through interrupter 15 through the winding of stepping magnet 8 to battery. Stepping magnet 8

now advances the switches S_3 and S_4 step by step, so that the amplification of the amplifiers A_3 and A_4 is gradually increased until the gains due to these amplifiers are sufficiently high to make the total amplification in the closed path as shown on Figure 1, equal to or slightly greater than the total loss in this path, whereupon singing will take place. The alternating current relay V operates in response to the singing oscillations, thereby opening the circuit of the stepping magnet 8 and bringing the switches S_3 and S_4 to rest. The alternating current relay V at its right hand front contact completes the locking circuit previously traced through the battery 16, so that said relay remains locked up until such time as the process of adjustment may be again repeated. The locking circuit of the relay V is of low resistance, and is a direct shunt across the output circuit of the amplifier A_2 , which forms part of the closed path in which singing is taking place. The shunt thus established causes singing to cease, and the switches S_3 and S_4 now remain adjusted so that the transmission equivalent of each of the lines L_3 and L_4 , exclusive of their terminating arrangements is opposite in sign to, and equal to one-half that of the amplifier A_2 . If, therefore, the amplifier A_2 has been properly set, the four-wire circuit will have the desired transmission equivalent. The potentiometers P_3 and P_4 will remain in their set positions, and the circuit is now in condition to be used.

The same result may be secured by opening and again closing the switch 12 either manually or by means of a time controlled device. It will also be obvious that the automatic switch arrangement may be eliminated, if desired, and the adjustment of the potentiometers may be performed manually.

By means of the arrangement disclosed, a four-wire circuit may be adjusted so that it will have any desired transmission equivalent, regardless of variations which may take place in the circuit, so long as the variations affect both sides of the circuit alike. It will also be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of adjusting the transmission efficiency of a circuit consisting of a pair of transmission lines for transmitting in opposite directions, which consists in connecting the ends of said pair of lines together, increasing the loss in the circuit thus produced so that singing does not take place, and gradually decreasing the loss until singing just commences.

2. The method of adjusting the trans-

mission efficiency of a circuit consisting of a pair of transmission lines for transmitting in opposite directions, and each including amplifying means, which consists in connecting the ends of said pair of lines through transmission devices having a total transmission equivalent double and opposite in sign to that to which it is desired to adjust each side of the four wire circuit, decreasing the amplification of said amplifying means so that singing does not take place over the circuit thus produced, and gradually increasing the amplification until singing just commences.

3. The method of adjusting the transmission efficiency of a circuit consisting of a pair of transmission lines for transmitting in opposite directions, which consists in connecting the ends of said pair of lines together through transmission devices having a total transmission equivalent opposite in sign and twice that to which it is desired to adjust each side of the four wire circuit, increasing the loss in the circuit thus produced so that singing does not take place, and gradually decreasing the loss until singing just commences.

4. The method of adjusting the transmission efficiency of a circuit consisting of a pair of transmission lines for transmitting in opposite directions and each including amplifying means, which consists in connecting the ends of said pair of lines together, decreasing the amplification of said amplifying means so that singing does not take place over the circuit thus produced, and gradually increasing the amplification until singing just commences.

5. In a signaling system, a four wire transmission circuit including a pair of transmission lines for transmitting in opposite directions, means to interconnect the ends of said lines independently of terminal connections, and means to increase the loss of said lines so that singing does not take place over the circuit thus formed and to gradually decrease the loss of said lines until singing just commences.

6. In a signaling system, a transmission circuit including a pair of transmission lines for transmitting in opposite directions, means to interconnect the ends of said lines, means to increase the loss of said lines so that singing does not take place over the circuit thus formed, means to gradually decrease the loss of said lines until singing just commences, and means responsive to the singing thereby produced to render said last mentioned means inactive.

7. In a signaling system, a transmission circuit including a pair of transmission lines for transmitting in opposite directions, amplifying means in said lines independently of terminal connections, means to interconnect the ends of said lines, means

to decrease the amplification of said amplifying means so that singing does not take place over the circuit thus formed and to gradually increase the amplification until singing just commences.

8. In a signaling system, a transmission circuit including a pair of transmission lines for transmitting in opposite directions, amplifying means for said lines, means to interconnect the ends of said lines, means to decrease the amplification of said amplifying means so that singing does not take place over the circuit thus formed, means to gradually increase the amplification until singing just commences, and means responsive to the singing thereby produced to render said last mentioned means inactive.

9. In a signaling system, a transmission circuit including a pair of transmission lines for transmitting in opposite directions, means to interconnect the ends of said lines through a transmission device having a transmission equivalent opposite in sign and double that to which it is desired to adjust each side of the circuit, means to increase the loss of said lines so that singing does not take place over the circuit thus formed, means to gradually decrease the loss of said lines until singing just commences, and means responsive to the singing thereby produced to render said last mentioned means inactive.

10. In a signaling system, a transmission circuit including a pair of transmission lines for transmitting in opposite directions, amplifying means for said lines, means to interconnect the ends of said lines through a transmission device having a transmission equivalent double and opposite in sign to that to which it is desired to adjust each side of the circuit, means to decrease the amplification of said amplifying means so that singing does not take place over the circuit thus formed, means to gradually increase the amplification until singing just commences, and means responsive to the singing thereby produced to render said last mentioned means inactive.

11. In a signaling system, a four wire transmission circuit including a pair of transmission lines for transmitting in opposite directions, terminating two wire lines to which the ends of said pair of transmission lines may be connected, means to disconnect said pair of transmission lines from the terminating two wire lines and interconnect the ends thereof through a transmis-

sion device having a transmission equivalent double and opposite in sign to that to which it is desired to adjust each side of the four wire circuit, means to increase the loss in the four wire circuit so that singing does not take place over the circuit thus formed, means to gradually decrease the loss until singing just commences, and means responsive to the singing thereby produced to render said last mentioned means inactive.

12. In a signaling system, a four wire transmission circuit including a pair of transmission lines for transmitting in opposite directions, amplifying means for said lines, terminating two wire lines to which the ends of said pair of transmission lines may be connected, means to disconnect said pair of transmission lines from the terminating two wire lines and interconnect the ends thereof through a transmission device having a transmission equivalent double and opposite in sign to that to which it is desired to adjust each side of the four wire circuit, means to decrease the amplification of said amplifying means so that singing does not take place over the circuit thus formed, means to gradually increase the amplification until singing just commences, and means responsive to the singing thereby produced to render said last mentioned means inactive.

13. In a signaling system, a transmission circuit including a pair of transmission lines for transmitting in opposite directions, amplifying means for said transmission lines, an automatic switch having a normal position and being adapted to be advanced therefrom or released and restored thereto, means under the control of said switch for determining the amplification of said amplifying means, means to interconnect the ends of said transmission lines and to release said switch, means responsive to the release of said switch for decreasing the amplification of said amplifying means so that singing does not take place over the circuit formed by interconnecting said pair of transmission lines, means to gradually increase the amplification until singing just commences, and means responsive to the singing thereby produced to bring said switch to rest.

In testimony whereof, I have signed my name to this specification this sixth day of September 1918.

ALVA B. CLARK.