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A. L. JONES

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SYSTEM FOR TESTING LINE BALANCE

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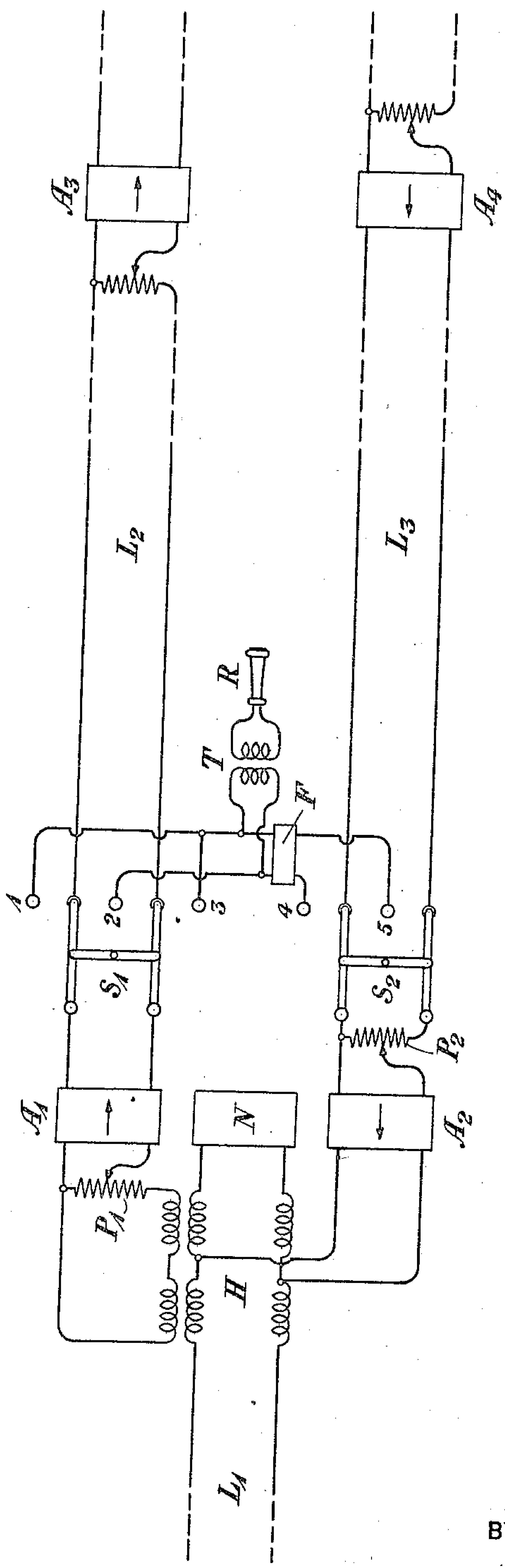

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UNITED STATES PATENT OFFICE.

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SYSTEM FOR TESTING LINE BALANCE.

Application filed November 15, 1921. Serial No. 515,369.

To all whom it may concern:

Be it known that I, ALVA L. JONES, residing at Asbury Park, in the county of Monmouth and State of New Jersey, have invented certain Improvements in Systems for Testing Line Balance, of which the following is a specification.

The principal object of my invention is to provide a new and improved method for testing the balance between a transmission line and its network. Another object of my invention is to provide suitable apparatus with which to practice this method. In a more specific aspect my invention relates to testing the balance between a two-wire line and its network, at the transformer making connection with a four-wire line. All these and other objects of my invention will be illustrated by a specific example of procedure thereunder which I shall now describe in some detail with the understanding that the scope of the invention is defined in the appended claims.

An ordinary two-wire transmission line or metallic circuit is indicated by L_1 in the accompanying drawing, and a four-wire transmission line is shown at L_2 L_3. In the four-wire line, one pair of wires forms a circuit for transmission in one direction and the other pair of wires forms a circuit for transmission in the opposite direction. L_2 and L_3 are two such pairs, making the four-wire line. Repeating elements A_3 and A_4 are interposed at suitable intervals, amplifying the currents in opposite directions as indicated by the arrows.

A four-wire line may be especially useful in a cable, whereas a two-wire line may be suitable for an open wire pole line. The drawing has relation to a station where voice currents pass either way between a two wire line L_1 and a four-wire line L_2 L_3.

The network N balances the line L_1 across the three-winding transformer H, whose output is connected by a potentiometer P_1 to the input of the amplifier or repeating element A_1 from which the output current goes over the line L_2, and becoming attenuated at a certain distance, is amplified by the repeating element A_3, and so on.

Voice currents coming in the opposite direction along the line L_3 pass to the potentiometer P_2, then to the amplifier or repeating element A_2, whose output goes to the points of the three-winding transformer H across which the line L_1 and its network N are balanced.

If the balance between the line L_1 and its network N is perfect, the current from the amplifier A_2 will divide equally between the line L_1 and the network N and produce a null effect on the amplifier A_1. In practice, a perfect balance is impossible, and to the extent that unbalance exists, some current induced by the output from the amplifier A_2 will get to the input of the amplifier A_1. My invention provides a method for testing the degree of unbalance between the line L_1 and its network N.

It will be seen from the diagram that by shifting both switches S_1 and S_2 up, the output of the amplifier A_1 becomes connected directly to the input of the amplifier A_2. It will be inevitable that some electrical disturbance will exist somewhere in the system, and therefore there will be a current put from the line L_1 into the amplifier A_1. However slight this may be, it will be amplified at A_1 and again at A_2, but if the line L_1 and the network N were in perfect balance none of the amplified energy from the output of the element A_2 would get across to the input of the element A_1. Since the balance cannot be ideally perfect some of that amplified energy will get across and be amplified again by the elements A_1 and A_2 in tandem. If the combined gains of the amplifiers A_1 and A_2 are smaller than the losses in the other parts of the circuit, this energy will be dissipated but if the gains are greater than the losses, the energy will be increased until limited by the power capacity of the amplifiers.

The high impedance monitoring coil T is bridged across the conductors between the switches S_1 and S_2 and associated therewith is a receiver R. A low-pass filter F is interposed in these conductors for a purpose which will be explained presently. If the circulation of energy through the amplifiers A_1 and A_2 in tandem builds up sufficiently it will be perceived as "singing" in the receiver R.

The two amplifiers A_1 and A_2 can be adjusted for gain by means of the potentiometers P_1 and P_2 and adjustments will be made to the point at which singing barely begins. Let the gain in standard miles in amplifier A_1 be a_1 and in amplifier A_2 let it be a_2. It will now be shown that the singing point may be expressed in standard miles by the formula

$$a_1+a_2-7$$

This means that the net gain around the circuit of A_1 and A_2 is equal to the sum of the gains of the two amplifiers less seven miles, which is approximately what is lost across the three-winding transformer H. The design of the system is such that the energy which comes in over the line L_1 practically divides equally to the circuit of the potentiometer P_1 and to the output of the amplifier A_2. Again the energy which comes from the output of the amplifier A_2 practically divides equally between the line L_1 and its network N. Thus, the net effect of the transformer H is to quarter the energy on each trip around the circuit of the amplifiers A_1 and A_2 in tandem. Reference to table of standard miles shows that quartering the energy means a loss of about $6\frac{1}{3}$ standard miles. There is a little further inevitable loss in the transformer H so that the figure is taken at 7, instead of $6\frac{1}{3}$.

By shifting the switch S_1 down so that its blades make contact with the studs 2 and 3 instead of 1 and 2 the connection between the amplifiers A_1 and A_2 is reversed or transposed, thus reversing the polarity of the disturbance at this point. One of these conditions will be more favorable to singing and will result in a lower value for the singing point than the other. The lower value is the true measure of the unbalance.

Usually the balance between the line L_1 and the network M becomes poor at frequencies outside the useful telephonic range. In case the lines L_2 and L_3 are loaded the behavior of the system will not be adversely affected by the poor balance, for they will not transmit such frequencies; but when the amplifiers A_1 and A_2 are connected directly by the operation of the switches S_1 and S_2, the singing of the system will be determined by the poor balance at high frequency rather than by the unbalance in the useful range. To avoid this error, the low pass filter F is included in the connection. It is so designed as to prevent the transmission of frequencies beyond the useful range, so that the results of the test will depend only upon conditions which affect the operation of the four-wire circuit.

The singing point will be determined initially in the manner described, and thereafter at intervals in practice, it will be redetermined in the same manner and if it is less than on the eariler occasion the attendant will know that the line L_2 and the network N are out of balance to a degree, as compared with their earlier condition. Accordingly, steps may be taken to rectify the irregularity on the line L_1 that has produced the unbalance, or steps may be taken to adjust the network N so as more accurately to balance the line L_1.

It will be seen that my method of test utilizes the repeater elements that are in normal service on the four-wire line and that very little extra apparatus is employed.

I claim:

1. The method of measuring unbalance between a two-wire line and its network at the junction with a four-wire line having repeater elements therein, which consists in disconnecting said repeater elements on their sides away from the two-wire line and connecting them in tandem, and adjusting their gain to the singing point.

2. In a transmission system comprising a two-wire line connected through a three-winding transformer to a four-wire line having repeater elements therein, the method of testing unbalance between the two-wire line and its network which consists in disconnecting said repeater on the side away from the two-wire line and connecting its elements in tandem, and adjusting their gain to the singing point.

3. In a transmission system comprising a two-wire line connected through a three-winding transformer to a four-wire line having repeater elements therein, the method of testing unbalance between the two-wire line and its network which consists in disconnecting said repeater on the side away from the two-wire line and connecting its elements together with a low pass filter all in tandem, and adjusting their gain to the singing point.

4. In a transmission system comprising a two-wire line connected through a three-winding transformer to a four-wire line having repeater elements therein, the method of testing unbalance between the two-wire line and its network which consists in disconnecting said repeater on the side away from the two-wire line and connecting its elements in tandem, adjusting their gain to the singing point, and taking the sum of the gains in the two repeaters, less the loss at the three-winding transformer, as the significant singing point gain.

5. In combination, a two-wire line, a four-wire line, a network simulating the two-wire line, a three-winding transformer interposed between the two-wire line and its network and operatively connecting the two-wire line and the four-wire line, two opposite repeating elements in the respective pairs of the four-wire line, means to disconnect them on the side away from the two-wire line, to reconnect them in tandam, and means to adjust said elements to determine the gain at the singing point.

6. In combination, a two-wire line, a four-wire line, a network simulating the two-wire line, a three-winding transformer interposed between the two-wire line and its

network and operatively connecting the two-wire line and the four-wire line, two opposite repeating elements in the respective pairs of the four-wire line, means to disconnect them on the side away from the two-wire line, to reconnect them in tandem, means to reverse the polarity of this connection, and means to adjust said elements to determine the gain at the singing point.

7. In combination, a two-wire line, a four-wire line, a network simulating the two-wire line, a three-winding transformer interposed between the two-wire line and its network and operatively connecting the two-wire line and the four-wire line, two opposite repeating elements in the respective pairs of the four-wire line, means to disconnect them on the side away from the two-wire line, to reconnect them in tandem, means to suppress currents of frequencies higher than the useful voice range, and means to adjust said elements to determine the gain at the singing point.

8. In combination, a two-wire line, a four-wire line, a network simulating the two-wire line, a three-winding transformer interposed between the two-wire line and its network and operatively connecting the two-wire line and the four-wire line, two opposite repeating elements in the respective pairs of the four-wire line, means to disconnect them on the side away from the two-wire line, to reconnect them in tandem, means to reverse the polarity of this connection, means to suppress currents of frequencies higher than the useful voice range, and means to adjust said elements to determine the gain at the singing point.

9. In combination, a two-wire line, a four-wire line, a network simulating the two-wire line, a three-winding transformer interposed between the two-wire line and its network and operatively connecting the two-wire line and the four-wire line, two opposite repeating elements in the respective pairs of the four-wire line, switching means to disconnect the repeating elements on the side away from the two-wire line, to reconnect them in tandem, a high impedance receiving set across the connection made in this way between the two repeaters, and means to adjust the repeating elements to determine the gain at the singing point as observed with the receiving set.

10. In combination, a two-wire line, a four-wire line, a network simulating the two-wire line, a three-winding transformer interposed between the two-wire line and its network and operatively connecting the two-wire line and the four-wire line, two opposite repeating elements in the respective pairs of the four-wire line, switching means to disconnect the repeating elements on the side away from the two-wire line, to reconnect them in tandem, a high impedance receiving set across the connection made in this way between the two repeaters, a low pass filter in this connection, and means to adjust the repeating elements to determine the gain at the singing point as observed with the receiving set.

In testimony whereof, I have signed my name to this specification this 14th day of November, 1921.

ALVA L. JONES.