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METHOD AND APPARATUS FOR TESTING TELEPHONE CIRCUITS

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Fig. 1.

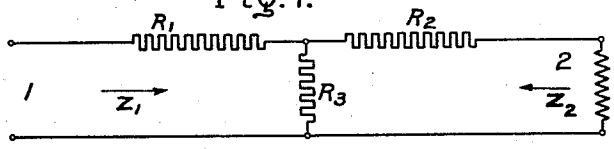
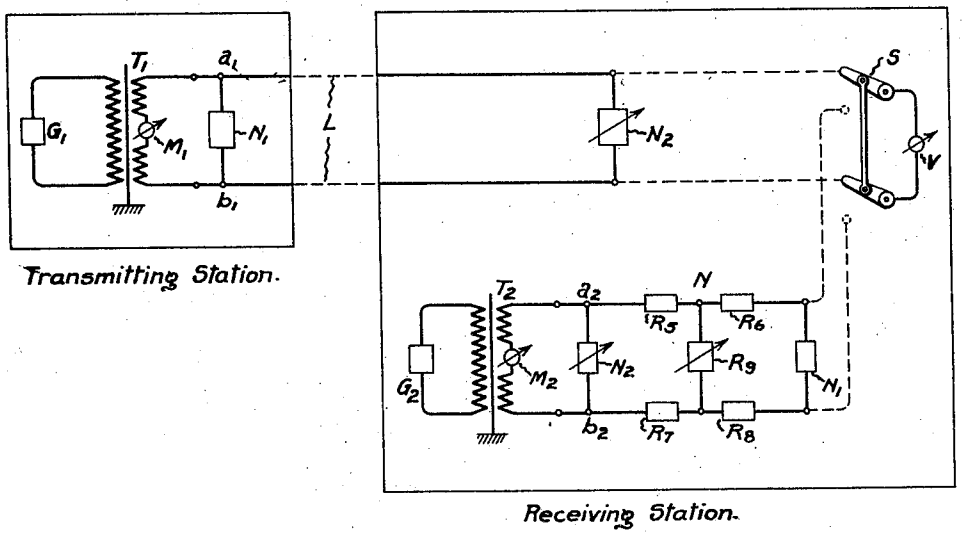


Fig. 2.



Transmitting Station.

Receiving Station.

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UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR TESTING TELEPHONE CIRCUITS.

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This invention relates to electrical testing systems, and particularly to a method and arrangements in such systems for measuring the attenuation in telephone lines.

Arrangements for measuring the attenuation of telephone lines are well-known. Such arrangements are described in an article by F. H. Best in the Transactions of the American Institute of Electrical Engineers for February, 1924, beginning at page 425 of that article. One arrangement is shown diagrammatically in Fig. 9 of that article, and this arrangement is fairly complicated, as will be obvious from the description relating thereto. The important draw-back of this arrangement is that the impedance of the receiving circuit, as stated on page 426, must be equal to the impedance of the sending circuit, and that, in order to obtain practical values, both the impedance of the receiving circuit and the impedance of the sending circuit must be equal to the impedance of the telephone line at the moment that it is being measured. That arrangement includes switching means for connecting at will any one of three fixed impedances, namely, 600, 1200 and 1800 ohms, these three values being merely the mean values of the types of telephone lines that are most frequently used in practice. The impedance of a telephone line in general deviates somewhat from these values. Furthermore, the impedance of every telephone line is also dependent upon the frequency transmitted thereover. Consequently, when higher frequencies are used, there are errors in the measurements which are due to the deviations between the impedance of the telephone line to be measured and the impedance of the sending or receiving circuit.

The present invention provides an arrangement which makes it possible to measure in a very simple manner correct values for the impedance of a telephone line. Moreover, the arrangement of this invention is substantially simpler than that of the description above referred to. For instance, the calibrating network mentioned in the above article is quite complicated so far as a calibrating net work itself is concerned, the calibrating network being the measuring apparatus which is adjusted for every measurement.

The features of my invention which are believed to be novel and patentable will be pointed out in the appended claims. A good understanding of the invention may be had from the detailed description hereinafter following when read in connection with the accompanying drawing in which Fig. 1 represents a network which is the equivalent of a four-terminal network composed of elements of resistance, and Fig. 2 represents a specific embodiment of the invention.

Referring to Fig. 1, there is shown a four-terminal network including resistances R_1, R_2 and R_3 arranged so as to form a T network. These resistances may be adjusted so as to have any desired attenuation. Let it be assumed that, when looking at the network from the side 1, the network has the characteristic impedance Z_1 and that, when looking at the network from the side 2, the network has the characteristic impedance Z_2. As is well known in the art, the characteristic impedance Z_1 may be made equal to the characteristic impedance Z_2. If this network is closed on side 2 by means of an impedance which is equal to its corresponding characteristic impedance, namely, the impedance Z_2, the impedance of the network measured from the side 1 will be equal to the characteristic impedance corresponding to that side, namely, the impedance Z_1. Moreover, when a voltage is impressed on the terminals of the side 1, no reflection will be produced at the side 2, since the network is terminated by its characteristic impedance. The current and voltage distribution of the network closed in a manner described herein will be the same as if the network possessed an infinitely great attenuation. Consequently, if b be the attenuation of the network, J_1 and J_2 and V_1 and V_2 the values of the current and voltage at the input and the output terminals of the network, respectively, the ratio of the current and voltage at the input terminals of the network to the current and voltage at the output terminals of the network will be dependent only on the attenuation b of the network and on the value of the square root of the ratio of the characteristic impedances at its input terminals and its output terminals. The ratio, however, is independent of the magnitudes of the characteristic impedances of the network itself. In the case of a symmetrical network, i. e., a network in

which the characteristic impedances are equal,

$$\sqrt{\frac{Z_1}{Z_2}}=1.$$

In this case the attenuation b depends only on the ratio that the current or voltage at the input terminals of the network bears to the current or voltage at the output terminals of the network. The attenuation of two networks of any characteristic impedances may therefore be compared, in accordance with this invention, by terminating the two networks in the manner described hereinabove and by applying the same voltages or currents to their input terminals.

Fig. 2 shows a specific embodiment of the invention particularly adapted for the measurement of attenuation of a telephone line. G_1 and G_2 are two alternating current generators which supply pure sinusoidal waves free from distortion. The generator G_1 is at the transmitting station, and the generator G_2 is at the receiving station. A telephone line L, shown in dotted lines, is connected to the generator G_1 through a shielded transformer T_1. A calibrating network N of adjustable attenuation is connected to the generator G_2 through a shielded transformer T_2. This calibrating network N comprises resistances R_5, R_6, R_7 and R_8 in series relationship with the secondary winding of the transformer T_2 and a resistance R_9 in shunt relationship with the secondary winding of the transformer T_2. This network is shown comprising pure resistances but it will be understood that the network may also be made to include inductances and capacities of suitable magnitudes. There are included in the secondary windings of the transformers T_1 and T_2 meters M_1 and M_2, respectively, these meters being used to aid in adjusting the current or voltage at the input terminals of the telephone line L and the calibrating network N, respectively, to the same values.

Bridged across the input terminals of the telephone line is a network N_1 which has an impedance equal to the characteristic impedance of the calibrating network N. Thus this network N_1 is included between the secondary winding of the transformer T_1 and the telephone line L. Bridged across the input terminals of the calibrating network N is a network N_2 which has an impedance equal to the characteristic impedance Z_1 of the telephone line L when looking at the line from the transmitting station. Thus this network N_2 is connected between the secondary winding of the transformer T_2 and the calibrating network N. Furthermore, a network N_2 having a characteristic impedance of the telephone line is bridged across the output terminals of the telephone line L so that the telephone line is terminated by its own characteristic impedance; and a network N_1 having a characteristic impedance of the calibrating network N is bridged across the output terminals of the calibrating network N, so that the calibrating network is terminated by its own characteristic impedance.

A switch S is arranged so as to connect either the output terminals of the telephone line L or the output terminals of the calibrating network N to an indicating meter V or other measuring device of high impedance. This indicating meter V is used for comparing the conditions at the output terminals of the telephone line L with those at the output terminals of the calibrating network N.

The switch S is moved first so as to connect the indicating meter V with the output terminals of the telephone line L. The generator G_1 transmits a current through the transformer T_1 to the input terminals a_1—b_1 of the telephone line L. The pointer of the indicating meter V will then be deflected and its deflection may be read. The exact value of the drop in potential over the telephone line need not yet be known. The switch S is then moved so as to connect the output terminals of the calibrating network N with the indicating meter V. The generator G_2 then supplies a current to the input terminals a_2—b_2 of the calibrating network N through the transformer T_2. The current transmitted by the generator G_2 is then adjusted until the current flowing to the input terminals of the calibrating network N equals that which previously flowed to the input terminals of the telephone line L. In other words, the currents are adjusted until the meter M_2 reads exactly the same as the meter M_1 reads, thus making the conditions at the input terminals a_2—b_2 the same as those at the input terminals a_1—b_1. The calibrating network N is then adjusted until the deflection of the indicating meter V equals the deflection of that meter when the switch S was connected to the output terminals of the telephone line L. When this adjustment is made, the conditions at the output terminals of the calibrating network N are made the same as the conditions at the output terminals of the telephone line L. Since the calibrating network N and the telephone line L may be said to have the properties of infinitely long lines because they are terminated by their own characteristic impedances, then the attenuation as determined from the calibrating network N will be equal to the total attenuation of the telephone line L without regard to the characteristic impedance of the telephone line L or the characteristic impedance of the calibrating network N.

It seems hardly necessary to state that when the loss of the network N is large, the resistance R_9 is small and forms only a small part of the characteristic impedance of the

network N. The resistance R_9 may be varied over a considerable range without materially affecting the magnitude of the characteristic impedance of network N. Thus, the resistance N_1 has a magnitude always substantially equal to the characteristic impedance of network N, even when the impedance of this network is varied by the manipulation of the resistance R_9.

It will be understood, however, that although the arrangements of this invention have been described particularly with reference to the adjustment of voltage conditions at the input and output terminals of both the telephone line and the calibrating network, respectively, the same arrangements may be employed for adjusting the current conditions of both the telephone line and the calibrating network.

While the arrangements of this invention have been shown and described with respect to the particular embodiment of Fig. 2, it is to be understood that the invention is capable of embodiment in other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The method of determining the attenuation of a telephone line with an adjustable artificial network and suitable impedance elements, which consists in setting up a predetermined electrical condition across the input terminals of a telephone line, setting up the same electrical condition across the input terminals of the artificial network, terminating said telephone line and said artificial network by their respective characteristic impedances, adjusting the attenuation of the artificial line to equal the attenuation of the telephone line, and observing at the output terminals of the telephone line and at the output terminals of the artificial network when the attenuation of the artificial line equals the attenuation of the telephone line.

2. The method of determining the attenuation of a telephone line with apparatus including an artificial network, the input and output terminals of the telephone line being respectively shunted by the characteristic impedance of the artificial network and the characteristic impedance of the telephone line, the input and output terminals of the artificial network being respectively shunted by the characteristic impedance of the telephone line and the characteristic impedance of the artificial network, which consists in setting up a predetermined voltage across the input terminals of the telephone line, setting up the same voltage across the input terminals of the artificial network, adjusting the attenuation of the artificial line to equal the attenuation of the telephone line, and observing when the attenuation of the artificial line equals the attenuation of the telephone line.

3. A system for measuring the attenuation of a telephone line comprising an artificial network, means for setting up the same voltages across the input terminals of the telephone line and the input terminals of the artificial network, the telephone line being terminated by its corresponding characteristic impedance, the artificial network being terminated by its corresponding characteristic impedance, means for adjusting the attenuation of the artificial line to equal the attenuation of the telephone line, and means for observing when the attenuation of the artificial line equals the attenuation of the telephone line.

4. In combination, a telephone line, an artificial network, two networks each having the characteristic impedance of the artificial line, one bridging the input terminals of the telephone line and the other bridging the output terminals of the artificial line, two networks each having the characteristic impedance of the telephone line, one bridging the output terminals of the telephone line and the other bridging the input terminals of the artificial network, means for impressing the same currents on the input terminals of the telephone line and on the input terminals of the artificial network, means for adjusting the attenuation of the artificial network to equal the attenuation of the telephone line, and means for indicating the equality of the attenuations of the telephone line and the artificial network.

5. In combination, a telephone line, an artificial network, two networks each having the characteristic impedance of the artificial line, one bridging the input terminals of the telephone line and the other bridging the output terminals of the artificial line, two networks each having the characteristic impedance of the telephone line, one bridging the output terminals of the telephone line and the other bridging the input terminals of the artificial line, two alternating current generators each so arranged as to transmit equal currents through the telephone line and through the artificial network, means for adjusting the attenuation of the artificial network to equal the attenuation of the telephone line, and a measuring device of high impedance for indicating when the attenuation of the artificial network equals the attenuation of the telephone line.

In witness whereof, I have hereunto set my hand this 15th day of March, 1926.

WALTHER WOLFF.