

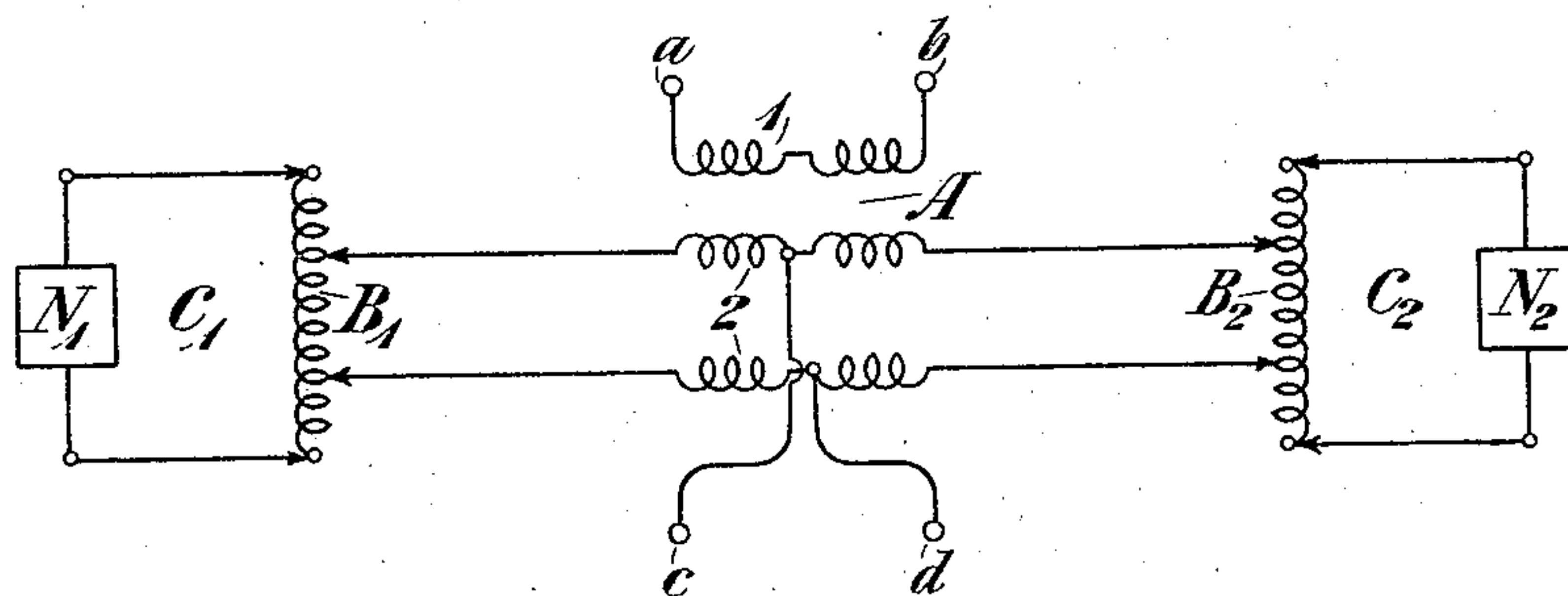
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ARTIFICIAL LINE

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ARTIFICIAL LINE.

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To all whom it may concern:

Be it known that I, GEORGE CRISSON, residing at Hoboken, in the county of Hudson and State of New Jersey, have invented certain Improvements in Artificial Lines, of which the following is a specification.

This invention relates to a method of and means for simulating a transmission line.

A telephone or telegraph transmission line is generally characterized by (a) its impedance, (b) its transmission equivalent. The former of these factors is determined by certain physical properties of the line and substantially independent of the length thereof (provided the line is above a certain length). The latter factor, however, is dependent upon the length as well as the aforementioned physical properties. The object of this invention is to provide an artificial line which is adjustable, not only in impedance but also in transmission equivalent, so that it may be used to simulate any type of line of any desired length.

Another object of the invention is to so arrange the artificial line that its transmission equivalent may be varied while its impedance remains constant.

In one form of the embodiment of the invention a pair of networks, each having the impedance of the line desired to be simulated, are associated through a suitable three-winding transformer with a transmission circuit in such manner that the flow of current through the circuit is governed by the difference between the impedances of the networks. These impedances determine the impedance of the artificial line and the difference between them determines the equivalent length of the line. Devices may be interposed between the networks and the said transmission circuit whereby the impedances of said networks, as seen from the transmission circuit, may be varied reciprocally, so that the impedance of the artificial line remains constant when its equivalent length is varied.

A good understanding of the invention may be had from the following description thereof considered in connection with the accompanying drawing showing in diagrammatic view one form and arrangement of apparatus embodying the invention.

Reference character A in this drawing

designates a transformer, one side of which is comprised of a coil 1 and the other side of a pair of coils 2. Impedance devices C_1 and C_2 , consisting of autotransformers B_1 and B_2 and networks N_1 and N_2 , are connected across the terminals of coils 2, so that current flows through the impedance devices in series when an electromotive force is applied to terminals a, b . If the drop in potential is the same in C_1 as in C_2 , the terminals c, d connected with the midpoints of coils 2, are at like potential, so that no current flows from a, b to a circuit associated with c, d . If the impedance of C_1 and C_2 differ, however, current does flow into the circuit associated with c, d , the strength of this current being dependent upon the difference between the impedance of C_1 and C_2 .

The circuit arrangement which associates a, b with c, d may, therefore, be utilized as an artificial line whose transmission equivalent is the same as that of an actual line having a length such that current applied to one end thereof bears the same ratio to the current flowing out of the other end, as the current flowing into a, b bears to the current flowing out of c, d . The autotransformers B_1 and B_2 are provided with adjustable taps so that the impedances of the devices C_1 and C_2 , as seen from the coils 2, may be adjusted until the transmission equivalent of the artificial line has the desired value. This could also be accomplished by varying the constants of networks N_1 and N_2 and dispensing with transformers B_1 and B_2 when the networks are of simple construction, as for example when they consist of pure resistances.

The impedance of the above-described arrangement, as seen from terminals a, b , is determined by the impedance of the networks N_1 and N_2 , the transformers A, B_1 and B_2 being assumed for the present purpose as "perfect." The impedance characteristic of the artificial line is therefore the same as that of the actual line simulated by the networks N_1 and N_2 , and by proper selection of networks the device of this invention may be employed to simulate any type of actual line.

By mathematical proof it may be shown, moreover, that the impedance of the artificial line remains substantially constant

when the transmission equivalent thereof is varied through a wide range, provided the impedances of the devices C_1 and C_2 are varied inversely to each other.

5 Let
 Z_1 =impedance of C_1
 Z_2 =impedance of C_2
 Z_3 =impedance of circuit connected to terminals c, d ,
 10 E =electromotive force applied to terminals a, b .
 I_1, I_2, I_3 and I_4 =currents through Z_1, Z_2, Z_3 and winding 1, respectively, clockwise flow being considered positive.

15 Then, assuming a turn ratio of 1:1,

$$\frac{E}{2} = Z_2 I_2 + Z_3 (I_2 - I_1) \quad (1)$$

$$\frac{E}{2} = Z_1 I_1 - Z_3 (I_2 - I_1) \quad (2)$$

and, from (1) and (2)

$$E = Z_1 I_1 + Z_2 I_2 \quad (3)$$

25 or

$$I_1 = \frac{E - Z_2 I_2}{Z_1} \quad (4)$$

and

$$30 \quad I_2 = \frac{E - Z_1 I_1}{Z_2} \quad (5)$$

Substituting the value of I_1 from (4) in (1) and simplifying

$$35 \quad I_2 = E \frac{\frac{1}{2} Z_1 + Z_3}{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3} \quad (6)$$

Similarly from (5) and (2)

$$40 \quad I_1 = E \frac{\frac{1}{2} Z_2 + Z_3}{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3} \quad (7)$$

Since

$$45 \quad I_4 = \frac{I_1 + I_2}{2} \quad (8)$$

$$50 \quad I_4 = E \frac{\frac{1}{2} (Z_1 + Z_2) + 2Z_3}{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3} \quad (9)$$

The impedance, therefore, of the artificial line as seen from terminals a, b is equal to,

$$55 \quad Z = \frac{E}{I_4} = 2 \frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{\frac{1}{2} (Z_1 + Z_2) + 2Z_3} \quad (10)$$

For efficient operation, Z_1 and Z_2 should be equal to each other and Z_3 should be half of Z_1 or Z_2 . If Z_0 is designated the "normal" value of the impedance Z_1 and Z_2 .

and

$$65 \quad Z_3 = \frac{Z_0}{2}$$

If now Z_1 and Z_2 are varied inversely to each other, by a factor r ,

$$Z_1 = \frac{Z_0}{r} \quad (11)$$

$$Z_2 = r Z_0 \quad (12)$$

Substituting (11) and (12) in (10) and simplifying

$$Z = 2Z_0 \quad (13)$$

The value of the impedance of the artificial line is therefore constant, no matter what values are assigned to r , provided $Z_3 = \frac{1}{2} Z_0$, as assumed above. Although a turn ratio of 1:1 is assumed in the above demonstration for sake of simplicity, it is readily understood that any other ratio may be used as circumstances may require, a ratio of 2:1 having been found convenient in actual practice.

It is thus apparent that the artificial line of this invention simulates an actual line, whose impedance is determined by the impedances of the networks and whose length is determined by the relative values of the said impedances. Any other suitable circuit arrangement may be employed in place of the three-winding transformer for associating the networks with the input and output sides of the artificial line, many forms of such arrangements being well known in the arts. Other changes and modifications may be made in the apparatus herein shown and described, within the scope of the following claims without departing from the spirit and scope of the invention.

What is claimed is:

1. An artificial line comprising a pair of impedance devices associated in balancing relationship in a circuit whose transmission is null when the balance is perfect, and means to adjust the transmission by adjusting the unbalance between the said devices.

2. An artificial line comprising a circuit, a pair of networks, a device for so associating said networks with said circuit that the transmission equivalent thereof is determined by the difference between the impedances of the networks, and means interposed between said circuit and said network for adjusting the transmission equivalent of said line.

3. An artificial line comprising a circuit, a pair of impedance devices, means for adjusting the relative impedances of said devices, and means for so associating the circuit with said devices that the transmission through said circuit is determined by the relative impedances of said devices.

4. An artificial line comprising a pair of networks, a circuit connecting said networks in series with each other, a transformer having one winding in series in said circuit, and a transmission system comprising two parts

inductively related, one of them comprising the other winding of said transformer and the remaining part comprising conductors connected to the midpoints of the said first mentioned circuit.

5 5. The method of simulating a transmission line which consists in associating a pair of impedance devices in balancing relationship to a pair of input terminals and governing the flow of current in a transmission circuit by the difference in the impedance of said devices.

15 6. The method of simulating various lengths of an actual line, which consists in associating a pair of impedance devices in balancing relationship with a transmission circuit, and varying the impedance of said devices reciprocally to each other.

20 7. The method of simulating an actual line of variable length, which consists in connecting a pair of impedance devices having the impedance of the actual line between the input and output sides of a transmission circuit, in such manner that the transmission of said circuit is determined by the difference between the impedances of said devices, and varying the impedances of said devices reciprocally.

30 8. An artificial line comprising a plurality of impedance elements, and means to vary them to adjust the characteristic impedance to different values and to vary the relation

of said impedance elements to adjust the transmission equivalent independently of of the characteristic impedance.

9. An artificial line comprising adjustable impedance elements combined additively with respect to characteristic impedance and differentially with respect to transmission equivalent.

10. An artificial line comprising adjustable impedance elements combined additively with respect to characteristic impedance and differentially in inverse ratio to one another with respect to transmission equivalent.

11. An artificial line comprising adjustable impedance elements combined in series with respect to a transmitting source to determine the characteristic impedance and combined in balancing relation as to said source to determine the transmission equivalent.

12. The method of adjusting the impedance elements of an artificial line, which consists in varying them in additive relation to adjust the characteristic impedance and varying them in differential relation to adjust the transmission equivalent.

In testimony whereof, I have signed my name to this specification this 14th day of October, 1919.

GEORGE CRISSON.