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G. CRISSON ET AL

ADJUSTABLE ELECTRICAL NETWORK

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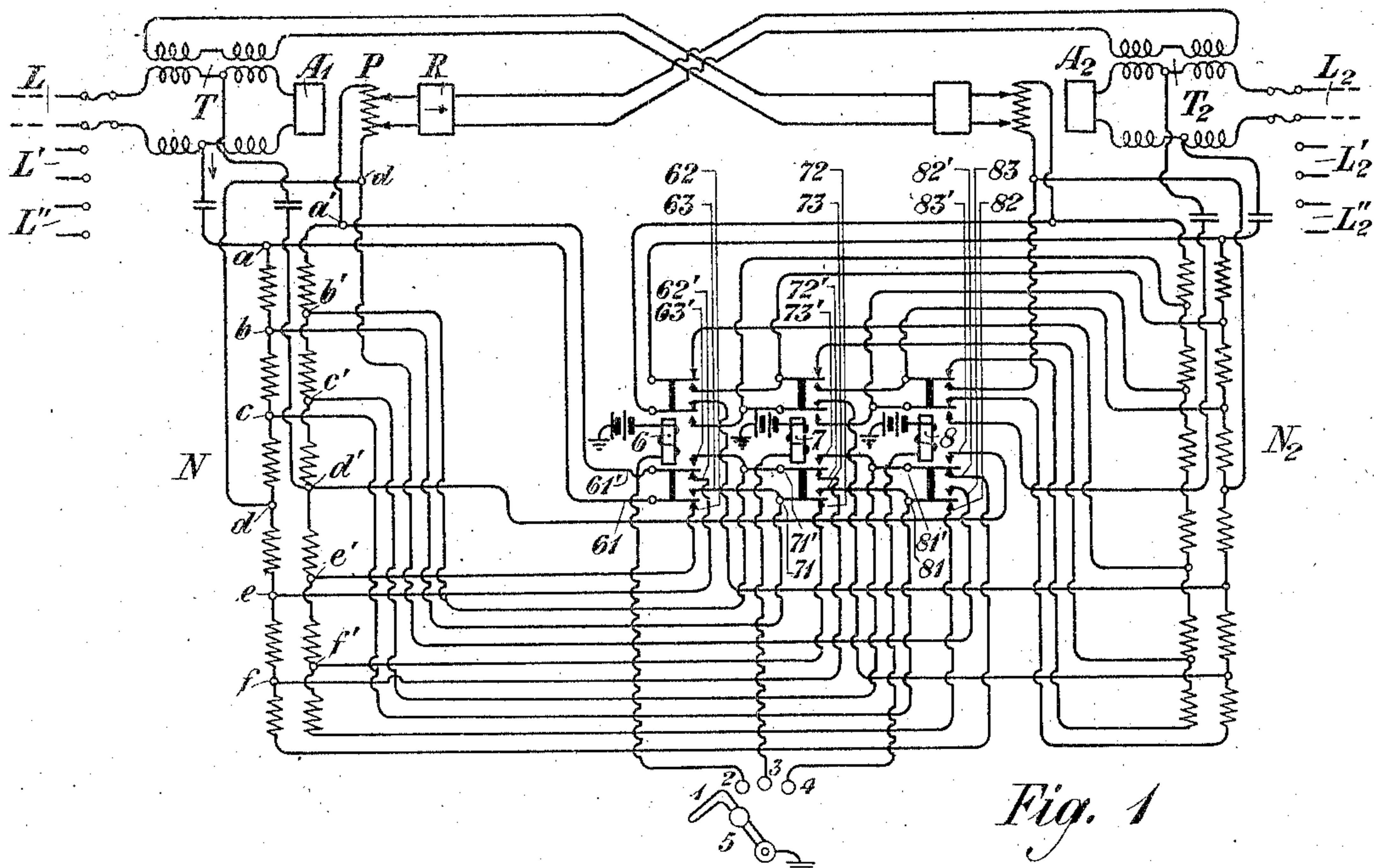


Fig. 1

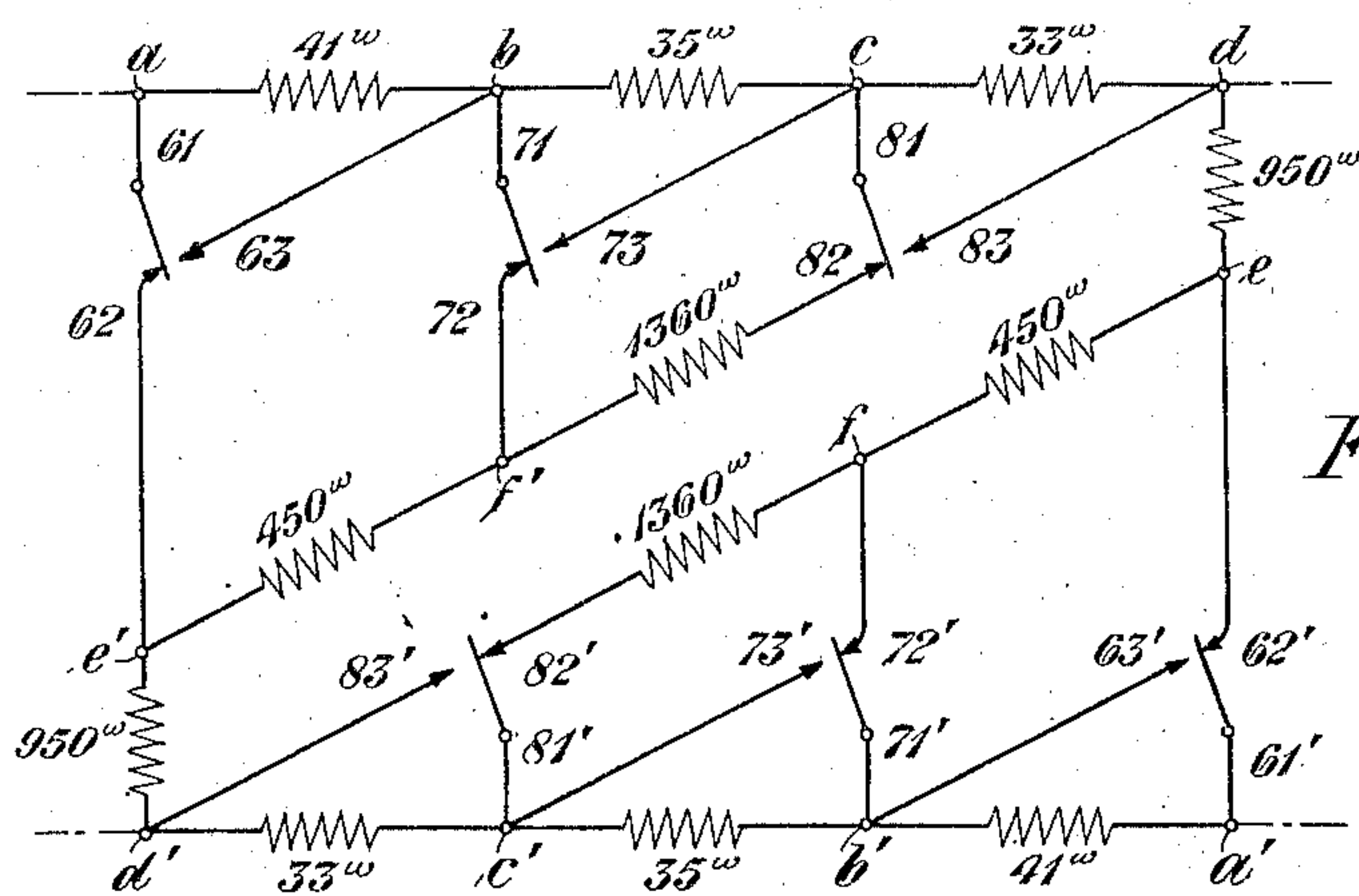


Fig. 2

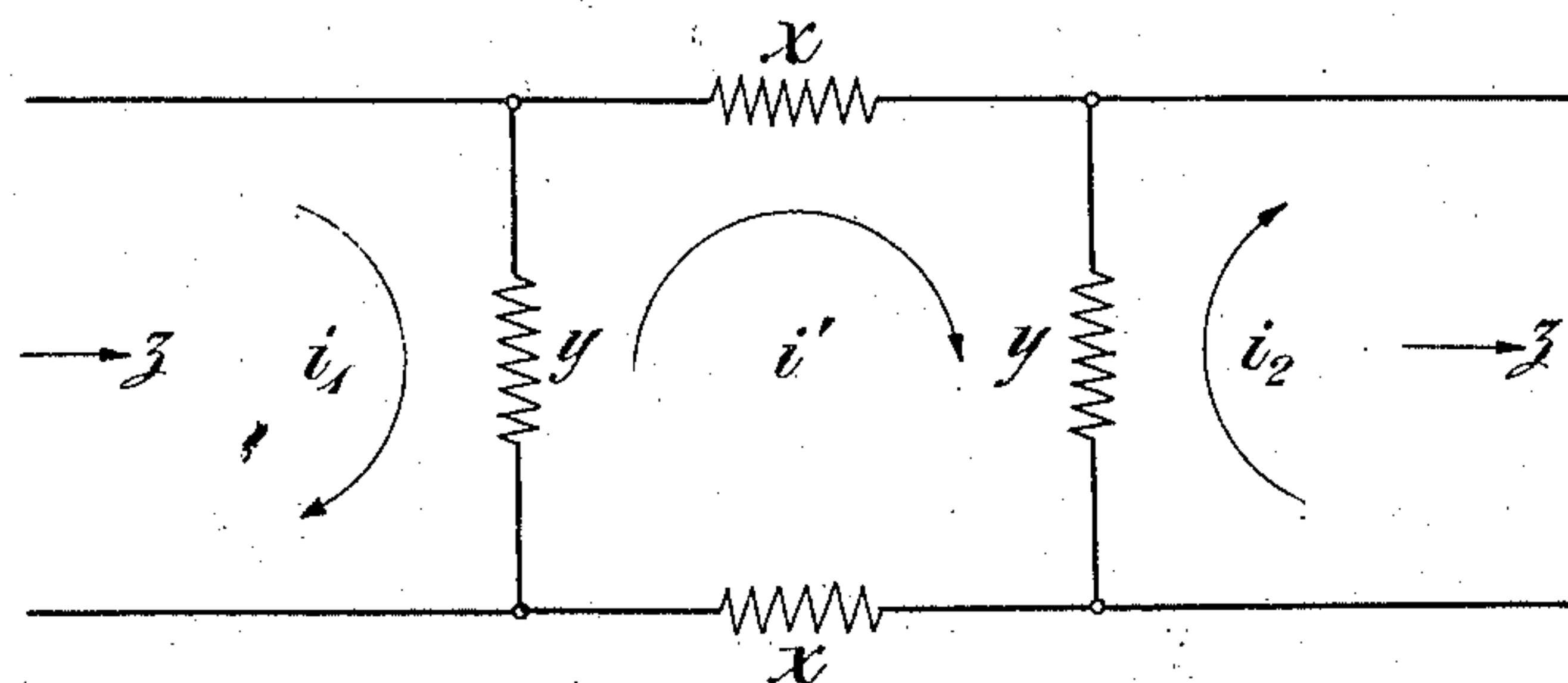


Fig. 3

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ADJUSTABLE ELECTRICAL NETWORK.

Application filed December 15, 1922. Serial No. 607,190.

To all whom it may concern:

Be it known that we, GEORGE CRISSON and LEE L. GLEZEN, residing at Hackensack and New Brighton, in the counties of Bergen and Richmond and States of New Jersey and New York, respectively, have invented certain Improvements in Adjustable Electrical Networks, of which the following is a specification.

10 An object of our invention is to provide a new and improved network or artificial line and to make it adjustable as to one characteristic without disturbing it with respect to a certain other characteristic. Another object is to provide a network of constant resistance characteristic impedance but adjustable for attenuation between its input and output terminals. Another object is to make such a network with the same impedance characteristic at the output terminals and at the input terminals. Still another object is to provide in a simple and economical manner for making the circuit changes involved in the adjustments mentioned. All these and other objects of our invention will become apparent on consideration of a special case which is disclosed in this specification by way of example. It will be understood that the invention is defined in the appended claims. Referring to the drawings, Figure 1 is a diagram of an adjustable cord circuit repeater embodying our invention, and Figs. 2 and 3 are detail diagrams which will be referred to in explaining the principle of our device.

35 Referring to Fig. 1, this shows an adjustable cord circuit repeater for two-way operation interposed between the two lines L and L_2 . The balanced three-winding transformers T and T_2 are provided for simultaneous two-way operation. The artificial line A_1 balances the line L . The input for the network N is taken from the transformer T at the points a and d' . The input current passes through the network N , which is adjusted in the desired manner by the relays 6, 7 and 8 controlling the armatures and contacts shown below these relays in Fig. 1. The attenuated output from the network N goes from the taps a' and d to the adjustable balanced potentiometer P and thence to the repeating element R , which amplifies these currents and sends them to the line

L_2 and the artificial line A_2 through the transformer T_2 .

The apparatus just described has relation to repeating from L to L_2 , and this involves the network N . Repeating the opposite way is exactly similar and involves the network N_2 , whose adjustments are controlled by the same relays 6, 7 and 8 through the armatures and contacts shown above these relays in Fig. 1. To avoid repetition, the structure and operation of the system will be described principally for repeating from L to L_2 .

The repeater herein disclosed is intended for interposition between any one of several incoming lines L , L' or L'' , and any one of several outgoing lines L_2 , L_2' or L_2'' . Accordingly, as different connections are made, a different net gain or amplification will be desired, and the repeater is arranged so that the net gain can be quickly adjusted. This net gain is equal to the gain to which the repeater is adjusted by the potentiometer P , minus the loss in the network N .

This network N must be symmetrical with respect to the two conductors of the line to guard against line unbalance, and also it must be symmetrical with respect to the input and output terminals, so that the impedance shall be the same looking both ways into the network. A network of the type shown in Fig. 3 satisfies these requirements, and this is the general type of network employed in Fig. 1, and this type must be preserved at all adjustments. Moreover, at all adjustments the network must match the impedance of the line or other apparatus to which it is connected. This condition is expressed in Fig. 3 by the impedance value z , which is the same looking in the direction of the two arrows at the places where they appear in the drawing.

With the notation indicated in Fig. 3 it can readily be shown that this requirement of the same input and output impedance leads to the equation

$$z^2 = \frac{xy^2}{x+y} \quad (1)$$

Also by Kirchhoff's laws

$$(i_1 - i')y = i_1z \text{ and } (i' - i_2)y = i_2z \quad (2)$$

Eliminating i' from equation 2,

$$\frac{i_2}{i_1} = \frac{y-z}{y+z} \quad (3)$$

Let the ratio $i_2/i_1 = n$.

In the example of the invention shown in Fig. 1, it is desired to have four successive adjustments of the network N which shall give respective losses in standard miles of 6, 4, 2 and 0. This requires that n shall have the respective values 0.52, 0.65, 0.81 and 1.0.

It follows from equation 3 that

$$y = z \frac{l+n}{l-n} \quad (4)$$

Substituting in equation 1, the result is reached that

$$x = z \frac{l-n^2}{4n} \quad (5)$$

Equations 4 and 5 enable us to compute the proper values for x and y in terms of z for any desired loss ratio n , and in this way the following table is obtained, assuming that the impedance z is 300 ohms:

Miles loss.	z	Δx	y	Δy
6	105	**	950	**
4	67	-38	1400	450
2	33	-34	2760	1360
0	0	-33	∞	∞

The value 300 ohms for y is obtained by taking half the impedance of the line L, which is assumed to be 600 ohms. Looking into the line L from the points a and d' , it will be seen that the line L and the artificial line A are in parallel and hence the impedance across those points is half the impedance of the line L.

In order to get the different adjustments represented in the foregoing table by means of simple switching apparatus, the network is arranged as shown in Fig. 1 and also otherwise shown in Fig. 2. It will be seen that the first decrement of x , namely 38 ohms, is not represented directly in the network of Fig. 2, but it is obtained as the resultant of 41 ohms and 450 ohms in parallel. Accordingly, when the change is made from 6 miles loss to 4 miles loss, this is accomplished by the throw of the single switch 61 from contact 62 to 63, which operates to shunt out the 41 ohm component and also to throw the 450 ohm component over to make it a part of the resistance y between the points a and d' . Similarly it will be seen that the decrement 34 ohms is not represented directly in Fig. 2, but is obtained as the resultant of 35 ohms and 1360 ohms in parallel, and that the throwing of the single switch 71 shunts out the 35 ohm component

and transfers the 1360 ohm component into the y branch of the network.

Figs. 1 and 2 are numbered in correspondence, so that the network can be studied on both of them together. At the outset the relays and switches are all in the condition shown in Figs. 1 and 2, and the full loss of 6 standard miles is interposed. At this time the controller arm 5 is at the initial position 1 as shown in Fig. 1. A move to position 2 closes the circuit of relay 6, throwing switches 61 and 61', and thus changing the network, decreasing the series resistances x and increasing the shunt resistances y , so as to change the loss from 6 miles to 4 miles. It can readily be followed through that the further steps of the controller 5 to positions 3 and 4 will further change the network to give it the respective losses of 2 standard miles and 0. But through all these changes the impedance z remains unchanged.

We claim:

1. A network with a pair of input terminals and a pair of output terminals and symmetrical with respect to said pairs of terminals and comprising a series element and a shunt element, in combination with means to adjust those elements simultaneously to vary the attenuation between input and output and keep the characteristic impedance unchanged.

2. In combination with two elements of apparatus of the same characteristic impedance, a network connected between them having shunt and series elements so related as to make the impedance the same looking either way from either element of apparatus, and means to adjust those elements simultaneously to vary the attenuation between input and output and keep the characteristic impedance unchanged.

3. A network with a pair of input terminals and a pair of output terminals and comprising a series impedance element and a shunt impedance element, in combination with means to reduce the magnitude of the series impedance and to transfer part of the series impedance element to increase the magnitude of the shunt impedance to adjust the attenuation between input and output and keep the characteristic impedance unchanged.

4. A network with a pair of input terminals and a pair of output terminals comprising a series impedance and a shunt impedance, said series impedance comprising parallel elements, and means to adjust the attenuation by shunting one of said parallel elements and transferring the other to become a series part of the said shunt impedance.

5. A network with a series impedance and a shunt impedance in combination with a single switch with two opposite contacts

adapted simultaneously to cut out series impedance and cut in shunt impedance by transferring elements used as series impedance elements and connecting them to increase the shunt impedance.

6. A network with a series impedance and a shunt impedance, in combination with a single switch with two opposite contacts adapted simultaneously to cut out series impedance and cut in shunt impedance by transferring elements used as series impedance elements and connecting them to increase the shunt impedance in proper proportion to keep the characteristic impedance of the network unchanged.

7. A network comprising a series impedance with certain elements in parallel and a shunt impedance, and a single switch with two alternative contacts to shunt one of the said parallel elements and throw the other parallel element in series as a part of the shunt impedance.

8. The method of varying the series and shunt impedances of a network to keep its characteristic impedance constant, which consists in shunting one of two parallel elements in the series impedance and transferring the other to a series relation in the shunt impedance.

9. A network comprising four impedances connected in rectangular fashion with the

opposite impedances equal and means to increase the value of each impedance of one pair and decrease those of the other pair so as to keep the characteristic impedance constant for the network.

10. A network consisting of four impedances arranged in rectangular fashion with the opposite impedances equal, certain elements of each impedance of one pair of opposites being in parallel, and a switch to shunt one such element and transfer another such element to a series relation in the remaining sides of the rectangle.

11. A cord circuit repeater adapted for interposition between various pairs of lines and requiring correspondingly different net gains therethrough, said repeater comprising a network with means to adjust it to keep its characteristic impedance unchanged but vary its loss and thereby vary the net gain through the repeater, said network lying between two pairs of terminals and having the same physical character looking into it from one pair of terminals as from the other.

In testimony whereof, we have signed our names to this specification this 13th day of December, 1922.

GEORGE CRISSON.
LEE L. GLEZEN.