

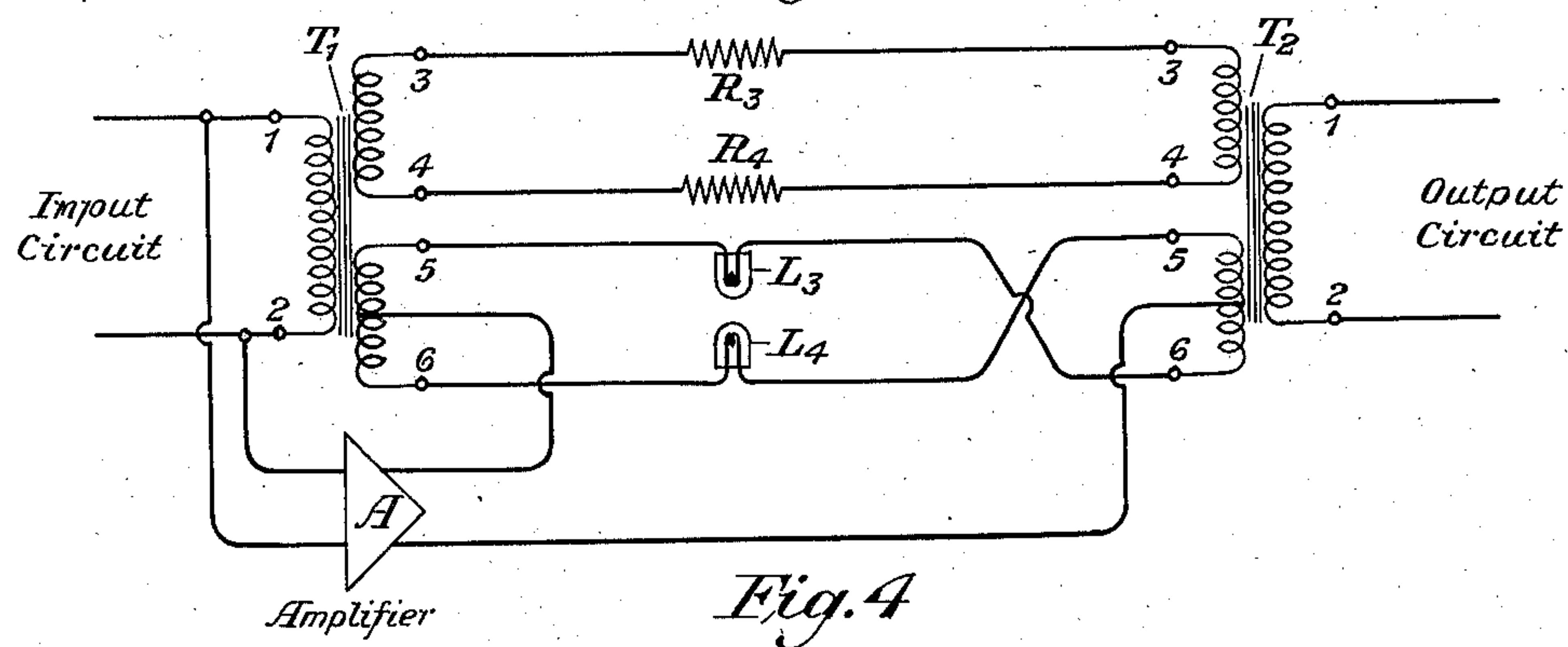
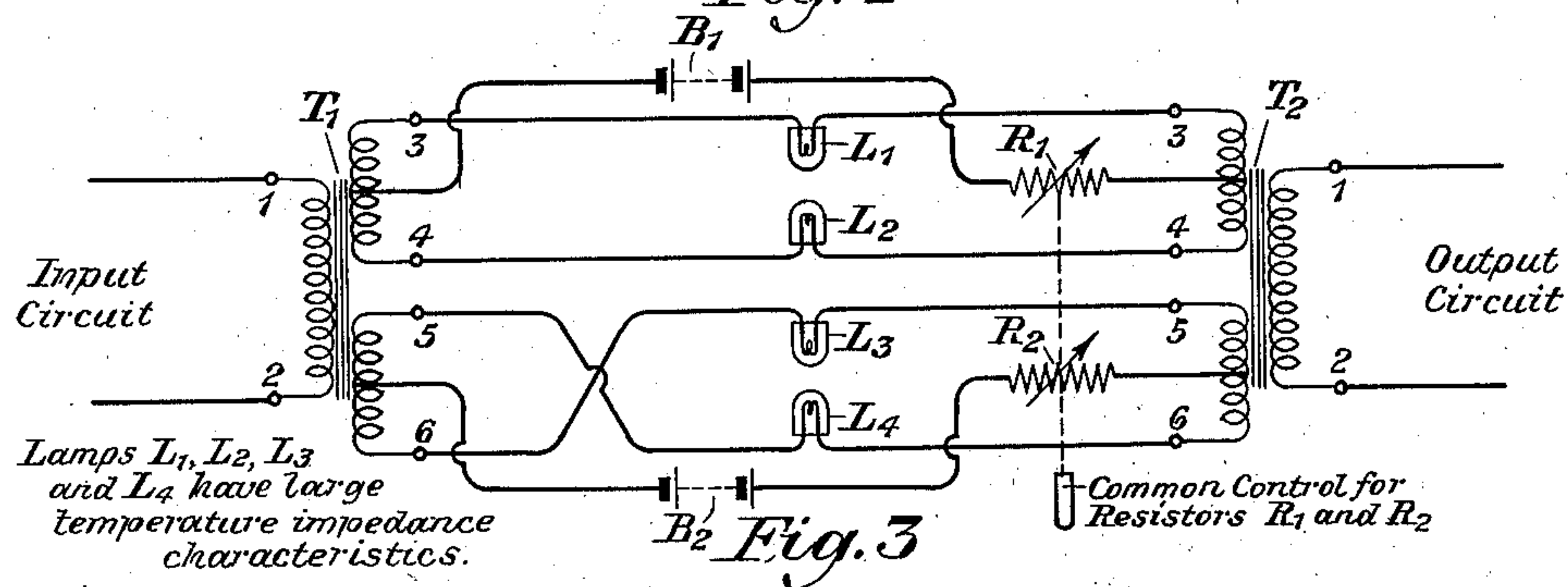
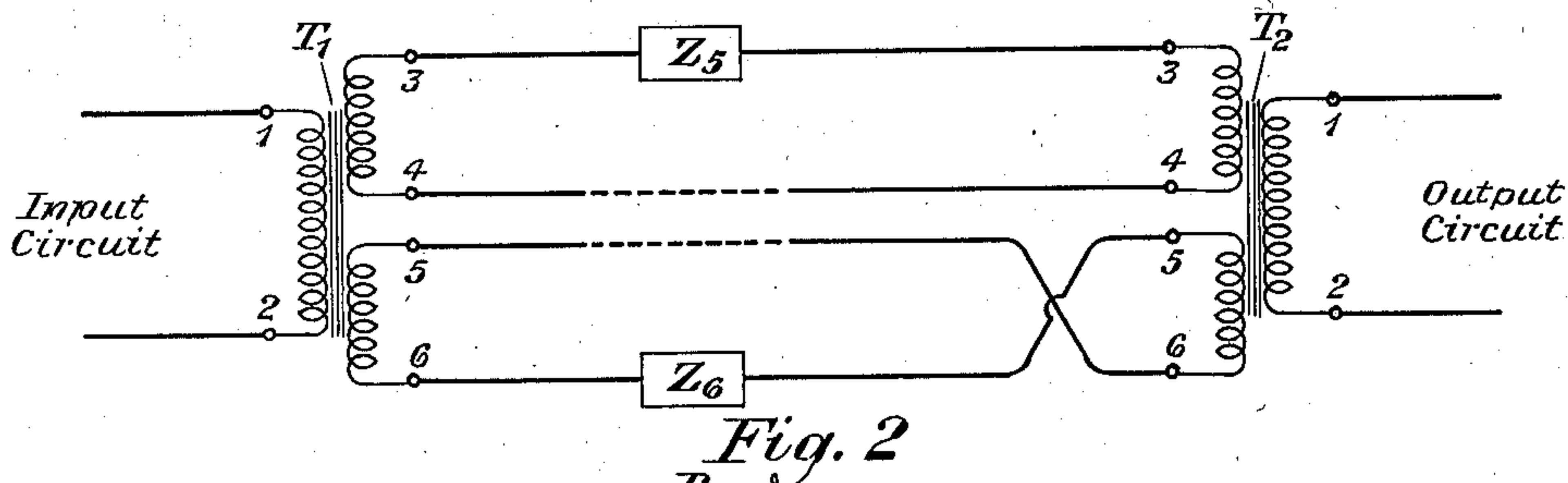
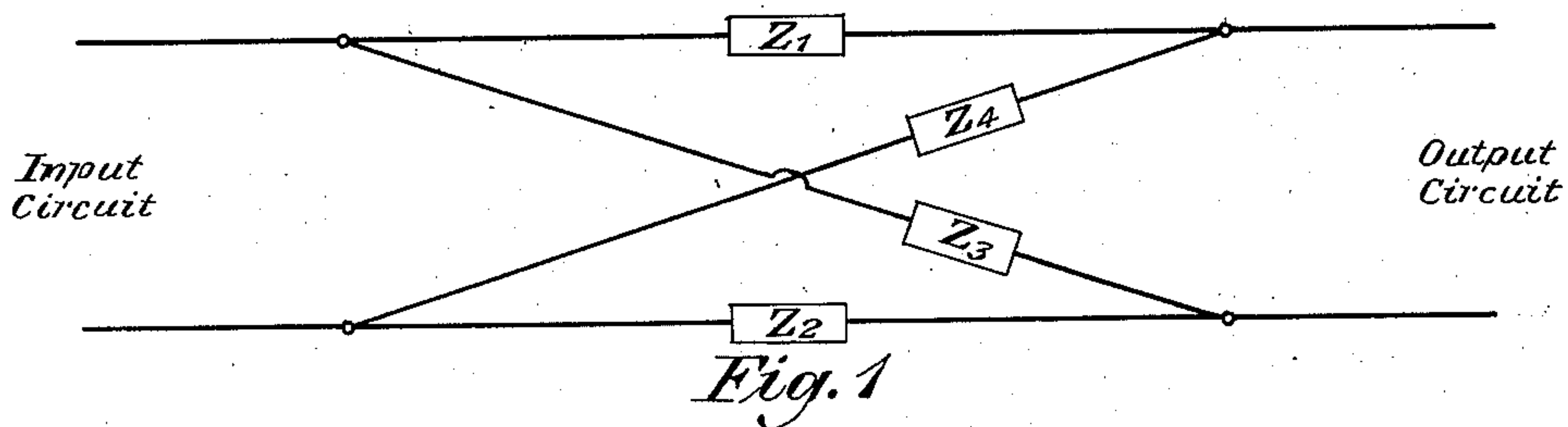
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ELECTRICAL ATTENUATOR

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ELECTRICAL ATTENUATOR

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7 Claims. (Cl. 178—44)

This is a continuation in part of my application Serial No. 634,616, filed September 23, 1932, for improvements in Electrical attenuators.

In the aforementioned application, an attenuation network is inserted in a transmission system in such a way that the locally produced currents which flow through the elements of attenuation will have substantially no effect on signal transmission through the system. These elements of attenuation are each in the form of a lamp which may have a filament of tungsten or the like, preferably of a high temperature coefficient of resistance. Each of these elements is in effect a non-linear impedance, the impedance depending upon the magnitude of the current flowing therethrough, the current determining the temperature of each element.

The arrangement described in my earlier application employs blocking condensers and choke coils and the like for the purpose of separating the alternating current or signal circuit from the circuit of the direct current employed in producing the controllable attenuation feature. The arrangement which is featured in this application, however, employs no such blocking condensers or choke coil devices, although it does employ repeating coils or transformers for effectively separating the alternating current or signal circuit from the circuit supplying current for the elements of attenuation.

The objects and features of this invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawing in which Figure 1 represents a schematic of one form of circuit or network to which the invention may be applied, Fig. 2 is an equivalent circuit, Fig. 3 shows one embodiment of the invention based on the type of network shown in Figs. 1 and 2, and Fig. 4 is a further modification of the invention.

Fig. 1 shows a lattice type of network in which the input and output circuits are interconnected by series impedance elements Z_1 and Z_2 and by diagonal impedance elements Z_3 and Z_4 . Signals may be transmitted from the input circuit to the output circuit, but by adjustments of the impedance elements, the loss in the lattice network may be brought to any desired magnitude as is well understood. Of course, these impedance elements may be simple adjustable resistors or any other elements of inductance or capacitance or combinations of such elements.

Fig. 2 is equivalent to the lattice type of network shown in Fig. 1. Here two or more im-

pedance elements are connected into the attenuation circuit, but the connection is made through two three-winding transformers. The windings 1—2 of two commercial three-winding transformers T_1 and T_2 are connected respectively to the input and output circuits. The windings 3—4 of these transformers are connected to each other through the impedance element Z_5 and the impedance element Z_6 is connected in series with the windings 5—6 of these transformers, the connections to windings 5—6 of transformer T_2 being reversed in phase as shown. It will be understood that additional impedance elements may be connected to these circuits, as, for instance, at the places indicated by the dotted lines.

Fig. 3 illustrates an arrangement based on the modification shown in Fig. 2. As in Fig. 2, the series arms of the lattice network are located in the upper branch of the attenuation network, that is, between the windings 3—4 of transformers T_1 and T_2 . The lattice or diagonal branches are in the lower branch, or between windings 5—6 of these transformers. Thus, the series and diagonal arms are effectively isolated from each other.

It will be observed that the tungsten filament lamps L_1 and L_2 are respectively connected between contacts 3 and 3 and 4 and 4 of transformers T_1 and T_2 and that similar lamps L_3 and L_4 are located in the circuits extending between contacts 5 and 6 of these transformers, as shown. A source of current B_1 , such as a storage battery, and a variable resistor R_1 are connected in series with each other between the midpoints of windings 3—4 of the two transformers. A similar source of current B_2 and a resistor R_2 are also connected in series relationship between the midpoints of windings 5—6 of the two transformers.

The current flowing from source B_1 is controlled by resistor R_1 and passes through two branches, one of which includes the upper half of winding 3—4 of transformer T_2 , lamp L_1 and the upper half of winding 3—4 of transformer T_1 , the other branch including the lamp L_2 and the lower halves of windings 3—4 of the two transformers. The source B_2 supplies current through variable resistor R_2 to lamp L_3 over the circuit which includes the upper half of winding 5—6 of transformer T_2 and the lower half of winding 5—6 of transformer T_1 , while current for lamp L_4 flows over the circuit including resistor R_2 , the lower half of winding 5—6 of transformer T_2 and the upper half of winding 5—6 of transformer T_1 .

The current supplied by source B_1 produces two equal and opposite fluxes in each of the windings 3—4 of transformers T_1 and T_2 . Similar equal and opposite fluxes are produced in each of windings 5—6 of these transformers. Consequently, there is no resultant direct current flux in the core of either transformer. Therefore any noise that may possibly be found in the direct current circuits of the network has little or no effect upon the signal transmission circuit and the signals are practically unaffected by any such noise.

The resistors R_1 and R_2 may be unequal or non-uniform elements of resistance, and they may be tapered as shown in my former application and their movable arms may be coupled to a common shaft which when rotated in either direction will vary the magnitudes of these resistors in mutually opposite directions by different amounts.

The arrangement shown in Fig. 3 resembles the one illustrated in Fig. 1, except that lamps L_1 , L_2 , L_3 and L_4 take the places of the corresponding impedance elements Z_1 , Z_2 , Z_3 and Z_4 . The loss of the network may be changed to any desired amount merely by adjusting the current flow through the resistors R_1 and R_2 . To reduce the loss or attenuation, it is simply necessary to reduce the flow of current through lamps L_1 and L_2 and increase the current passing through lamps L_3 and L_4 . To increase the loss or attenuation, the changes in currents should be reversed. When the currents traversing all of the lamps are equal the loss or attenuation will be a maximum.

If the transformers are such that their windings 3—4 and 5—6 may conveniently carry direct current, the number of lamps may be reduced from four to two. Hence, the lamp L_2 may, for instance, be eliminated and the source B_1 and resistor R_1 , may be connected in its place. In that event, the lamp L_4 may also be replaced by source B_2 and resistor R_2 .

While direct current has been illustrated as the means for heating the filaments of lamps L_1 , L_2 , L_3 and L_4 , such current is by no means the only current suitable for this purpose. It would, of course, be possible to utilize alternating current for heating purposes, the alternating current having a frequency which may be inside or outside the range to be controlled by the attenuator.

Fig. 4 shows another modification of this invention. Here the resistors R_3 and R_4 are the series elements of the attenuator and these are connected in series with the windings 3—4 of the transformers T_1 and T_2 . The diagonal elements are lamps L_3 and L_4 which have similar large temperature-resistance coefficients and are connected to windings 5—6 of the transformers in the same phase reversal arrangement as is shown in Fig. 3. A one-way amplifier A is connected to the input circuit of the system and this amplifier supplies the current required for heating the lamps L_3 and L_4 . By virtue of the balance obtained by connecting the output of the amplifier A to the midpoints of coils 5—6 of the two transformers, the amplifier is unable to sing or otherwise detrimentally affect the signal transmission through the system.

It will be observed that at a high level of energy, the amplifier A will transmit a large current to both lamps L_3 and L_4 and these will be heated to such high temperatures that their impedances may be made equal to those of resistors R_3 and R_4 , in which case the attenuation of the

network will be a maximum. Conversely, at a low level, lamps L_3 and L_4 will be of low impedance and the loss of the attenuator may be made a minimum.

It will be observed also that, were it possible to bring the temperatures of the lamps L_3 and L_4 to values which exceed safe working values, the impedances of these devices would exceed those of resistors R_3 and R_4 and the attenuation of the network would again decrease. This may be obviated by so constructing amplifier A that it embodies a power limiting device of any well known type, so that the maximum power produced by it will never exceed the value at which the attenuation of the circuit may reach a maximum.

The arrangement of Fig. 4 acts as a compressor of energy levels when operated as just described, that is, when resistors R_3 and R_4 are equal to the impedances of lamps L_3 and L_4 when lighted to maximum brilliancy. On the other hand, the arrangement acts as an expander when the resistors R_3 and R_4 are arranged to have magnitudes equal to the impedances of lamps L_3 and L_4 when cold. Certain telephone transmission systems such as radio links or carrier telephone circuits, for instance, function most satisfactorily when the speech currents are within a rather limited range of transmission levels. This effect may be secured by connecting two such attenuators in tandem, one at the input, for example, and the other at the output of such a system. Two such attenuators, one acting as an expander, and the other as a compressor, will render the device a compander.

It will be understood, of course, that two or more attenuators of the type shown in Fig. 3 may be located in the same place and that, if desired, all such attenuators may be simultaneously controlled by a common shaft to which all the resistors such as R_1 and R_2 may be coupled or to which a master resistor may be coupled.

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be understood that the principles of this invention are not limited to lattice types of networks, but are equally applicable to H, T, Pi, square and other and widely varied types of networks, without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. An electrical attenuator for uniformly attenuating currents of all frequencies impressed thereon, comprising two devices having non-linear current-voltage characteristics, two independent circuits in each of which one of said devices is connected, said circuits being arranged in phase opposition, and means for simultaneously varying the impedances of said devices.

2. An electrical attenuator for equally attenuating currents of all frequencies intended to be transmitted therethrough, comprising two devices having non-linear voltage-current characteristics, one of said devices being included in a circuit which is insulated from and out of phase with the circuit of the other device, and means for simultaneously modifying the impedances of said devices in opposite directions.

3. An electrical attenuator interposed between the input and output circuits of a transmission system, comprising a plurality of elements having non-linear current-voltage characteristics, and a power limiting amplifier receiving energy from the transmission system and connected to

said elements for controlling the impedances of said elements in accordance with the level of energy transmitted by the system and for limiting to a predetermined magnitude the amount of current transmissible through said elements.

5 4. The combination of an input circuit, an output circuit, a plurality of elements of large temperature coefficients of resistance, some of which are connected in a first circuit coupled to said input and output circuits and the rest of which are
10 connected in a second circuit similarly coupled to said input circuit and oppositely coupled to said output circuit the first and second circuits being substantially mutually non-reactive as well as in-
15 sulated from each other, and means for increasing the current flow through the first circuit and for decreasing the current flow through the second circuit and vice versa.

20 5. An attenuation network for a transmission system comprising a first circuit, a second circuit independent of and out of phase with the first circuit, both circuits being interposed in the transmission system, an element having a large temperature resistance coefficient included in each

circuit, a source of direct current, and means for varying the currents flowing from said source and through said elements in opposite directions.

6. Automatic electrical attenuating apparatus comprising an element having a high temperature-resistance coefficient, and a power limiting amplifier supplying current to said element and limiting to a predetermined value the maximum current suppliable to said element, the magnitude of the current supplied by the amplifier being
10 variable.

7. Automatic electrical attenuating apparatus comprising an input circuit, an output circuit, a pair of elements each having a large temperature-resistance coefficient, a pair of coils conductively connected to each other, said coils being
15 coupled respectively to said input and output circuits, each conductive connection of said coils including one of said elements, an amplifier, each output terminal of said amplifier being connected
20 to the midpoint of one of said coils, the input terminals of said amplifier being connected to said input circuit.

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