March 24, 1925. 1,530,633

D. F. WHITING

ELECTRICAL CIRCUITS, APPARATUS, AND METHOD

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Fig. 1.

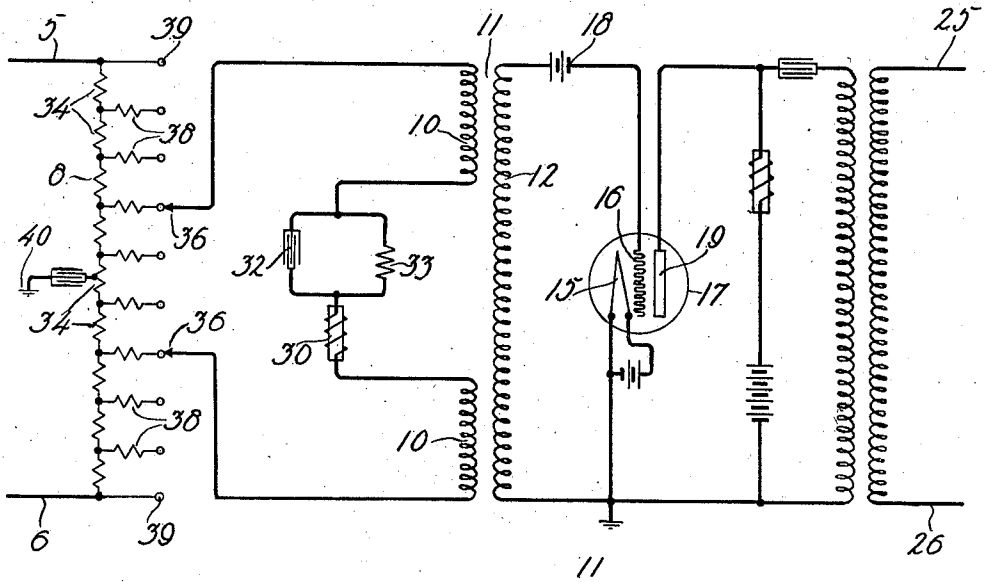
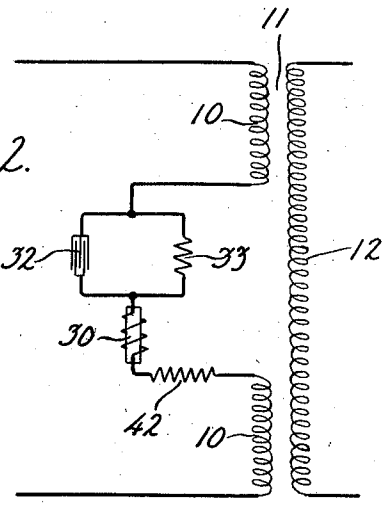


Fig. 2.



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by W. C. Beatty. Atty.

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UNITED STATES PATENT OFFICE.

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ELECTRICAL CIRCUITS, APPARATUS, AND METHOD.

Application filed August 30, 1920. Serial No. 406,861.

To all whom it may concern:

Be it known that I, DONALD F. WHITING, a citizen of United States, residing at New York, in the county of Bronx, State of New York, have invented certain new and useful Improvements in Electrical Circuits, Apparatus, and Methods, of which the following is a full, clear, concise, and exact description.

This invention relates to electrical circuits and more particularly to circuits and apparatus adapted to be associated with repeaters and amplifiers of alternating currents.

An object of the invention is to provide a potentiometer adapted to be adjustably connected to a frequency-responsive device and so arranged that the impedance of the portion of the potentiometer connected across said device is substantially the same for all settings of the potentiometer.

Another object of the invention is to provide a potentiometer which may be economically constructed, and the method of making the same.

A further object of the invention is to provide a transformer which will have a uniform transmission efficiency over a wide range of frequencies.

Other objects of the invention will be clear from the following detailed description and claims, when taken in connection with the accompanying drawings in which Fig. 1 represents schematically a circuit embodying the invention and Fig. 2 represents a slightly modified transformer.

Referring to the drawings by reference numerals, conductors 5 and 6 which may, for example, be telephone line wires, are connected to the outer terminals of a potentiometer 8 which is adjustably connected to the primary 10 of transformer 11. The secondary 12 of transformer 11 is connected to the cathode 15 and grid or control electrode 16 of the vacuum tube amplifier 17. A source of potential 18 is employed to maintain the grid negative with respect to the cathode. Cathode 15 and anode 19 may be connected by means of any usual or desired output circuit to the conductors 25 and 26, which may, for example, be the outgoing line wires.

Since the vacuum tube amplifier is a voltage operated device, transformer 11 is arranged to step up the voltage. It may, for example, have an impedance step up ratio of 282 to 300,000 ohms. The input impedance of vacuum tube 17 with reference to direct current or low frequencies is usually of the order of infinity and in any event is high relative to the impedance of the high winding of the transformer. At the higher frequencies of the voice range, however, the capacity between the tube electrodes, the capacity between the leads, and the capacity within the coil itself are appreciable. For these reasons the transformer presents an inductive reactance to the line in the lower part of the voice range and a capacity reactance in the upper part of the voice range. If these reactances are not annulled the repeater may give a desired gain in the middle portion of the frequency range, but the transmission may fall off considerably at the upper and lower ends of the range, with resulting distortion of the speech signals. This would also result in poor transmission of ringing currents, which in practice usually have a low frequency, as for example, 135 cycles.

An inductance 30 is provided in series with primary 10 having such a value that it will resonate with the capacity reactance above described at frequencies up to the upper end of the range of frequencies which it is desired to transmit. As disclosed in Canadian Patent 226,477, Nov. 21, 1922, the inductive reactance employed to annul the capacity reactance may have the form of a separate inductance as shown in the drawing, or it may be obtained by introducing leakage in the transformer itself.

A condenser 32 is provided to annul the inductive reactance of the transformer at frequencies in the lower part of the voice range. If the condenser 32 were to be used alone in many cases the transmission characteristic of the transformer would show a sharp upward curve at the resonant point, and it has been found desirable in some cases to provide means for damping the resonance. An arrangement in which a resistance is placed in series with the condenser for damping purposes has been heretofore shown. That arrangement, however, is not desirable in the circuit herein described, for the reason that a series resistance would also cut down the currents at frequencies in the upper part of the voice range. It has

been found, however, that a resistance 33 placed in parallel with condenser 32 will serve to flatten out the resonance curve of the low frequency tuned circuit, and at the same time a path of low impedance for currents of frequencies in the upper part of the voice range will be provided through condenser 32. It is to be noted that since the secondary winding 12 is substantially open-circuited for low frequencies, the whole of the inductance of the primary winding 10 is available for tuning with condenser 32. It is thus possible to use a smaller condenser which is cheaper and has a higher impedance to telegraph currents of the order of 20 cycles.

The potentiometer 8 is made up of a plurality of resistances 34 connected in series and having taps therebetween that may be selectively connected by means of a contact or contacts 36 to the primary 10. It has been found with the types of potentiometers heretofore employed that when the contacts corresponding to contacts 36 were adjusted to vary the repeater gain, thus varying the proportion of the resistance connected in series with the primary 10, this so changed the constants of the circuit comprising primary 10 and associated elements that the transmission characteristic was no longer uniform, even though the circuit had been adjusted to give a uniform transmission at a particular potentiometer setting. In order to maintain the impedance of this circuit constant, resistances 38 of suitably graduated values are connected between the potentiometer taps and the connections between the series resistances 34. The resistances in series with the extreme taps 39 are substantially zero and the resistance values increase toward the center so that the resistance measured between contacts 36 is always substantially the same.

In order that the circuit may be balanced, primary 10 is divided and elements 30, 32 and 33 placed between the parts. The mid-point of potentiometer 8 is preferably grounded at 40 to prevent singing due to longitudinal currents.

As shown in Fig. 2, the resistance 42 is provided in series with inductance 30. This arrangement may be employed where it is desirable to damp the high frequency tuned circuit. Resistance 42 will usually be of too small a value to damp the low frequency tuned circuit sufficiently. Resistance 33 is therefore present but will have a value greater than its value when used as in Figure 1.

The steps of potentiometer 8 are usually made small, representing losses of from .2 of a mile to 2 miles of standard cable. If the summation value of a plurality of resistances 34 is approximately correct, a considerable variation in the values of the individual resistances is permissible. In some cases a variation of 40% in a resistance 34 will not seriously impair the operation of the gain adjusting device. It has been found that instead of accurately measuring the resistance of each unit, the potentiometer may be much more economically made by the following method: Resistance wire is cut up into lengths each having a nominal resistance value calculated from the dimensions of the wire. These lengths may be wound on spools or formed into units of any desired character. They are then thrown into boxes labeled with the nominal values of the various sizes. The operator selects a unit having the nominal value for the first step of the potentiometer, and secures it to suitably mounted posts. She then measures its actual resistance. If the actual value is within the permissible variation the unit is not disturbed, but a second unit is selected having a nominal value greater or smaller, as the case may be, to compensate for the variation of the first. In selecting the further units the combined resistance of the units already attached is measured and the variation from the desired value is compensated for in the manner just described. A potentiometer may thus be made in which each of the units varies from its nominal value, but the combined resistance of any group of units will vary from its nominal value by an amount less than the greatest variation of any individual of the group.

While the invention has been shown in connection with a vacuum tube repeater, it is obvious that certain features of the invention are capable of a variety of uses and that the invention is not to be limited except as defined in the following claims.

What is claimed is:

1. A potentiometer, means for supplying electromotive force thereto, and a receiving circuit, said potentiometer having contacts for adjustable connection to said circuit, and having means for rendering the impedance, to current of a given nature, of said potentiometer and source viewed as from said circuit substantially the same for different adjustments of said connection of said contacts to said circuit.

2. In combination, a potentiometer, circuits connected to the fixed side and adjustable side respectively of said potentiometer, said potentiometer presenting to said circuits, respectively, substantially the same impedance, to current of a given nature, in one adjustment of said potentiometer as in another adjustment of said potentiometer.

3. In combination, a potentiometer, means for supplying electromotive force thereto, a receiving circuit, and means adjustably connecting said circuit to said potentiometer and maintaining the impedance, to current of a given nature, measured across said cir-

cuit, substantially the same for different adjustments of said connection of said circuit to said potentiometer.

4. In combination, a line, an impedance connected across said line, a circuit, and means whereby said circuit may be connected across different percentages of said impedance, said means comprising means for rendering the impedance looking from said circuit toward said first mentioned means substantially the same for the different connections of said circuit to said first mentioned impedance.

5. A potentiometer, means for supplying electromotive force thereto, an output circuit and means adjustably connecting said output circuit to said potentiometer and maintaining the impedance to current of a given nature measured across said connections substantially the same at all positions of adjustment.

6. A potentiometer comprising a resistance, a plurality of contacts, each having a connection to a separate point on said resistance, resistances in said connections, and a circuit connected to said potentiometer and having a terminal adapted to engage each of a plurality of said contacts, said resistances having values such that the impedance of said circuit remains substantially constant at different positions of said terminal.

7. In combination, a line, a fixed resistance connected thereacross, said resistance comprising a plurality of resistance elements connected in series, contacts, resistances of different values connecting said contacts to a plurality of points between said series elements, and a contact for traversing said first mentioned contacts.

8. A gain adjusting device variably connected in the input circuit of a repeater and means for maintaining the impedance of said circuit substantially constant when said device is varied.

9. A gain adjusting device variably connected in the input circuit of a repeater and means for maintaining the impedance of said circuit substantially constant when said device is varied, said means comprising a plurality of resistances adapted to be separately connected in said circuit.

10. In combination, a potentiometer, a frequency responsive device adjustably in circuit with said potentiometer, and means for maintaining the impedance of said circuit substantially constant throughout a plurality of adjusted conditions.

11. In combination, a transformer, means altering the transmission characteristics of said transformer for a certain frequency, a potentiometer adjustably connected to said transformer and means for maintaining the transmission characteristics of said transformer independent of changes in the adjustment of said potentiometer.

12. In combination, a transformer, a potentiometer adjustably connected to said transformer and means for maintaining the transmission characteristics of said transformer independent of changes in the adjustment of said potentiometer.

13. In combination, a transformer, a potentiometer adjustably connected to said transformer and means for maintaining the transmission characteristics of said transformer independent of changes in the adjustment of said potentiometer, said means comprising series resistances individual to the potentiometer contacts.

14. The method of making a sectional impedance device, which comprises preparing resistance elements whose values are only approximately known, connecting a plurality of said elements in succession in series, measuring at times the summation resistance of the elements already connected, and compensating for the variation of the measured value from the nominal value by selecting for the succeeding element one having the proper nominal value.

15. A potentiometer, comprising resistance elements in series, said potentiometer being calibrated on the basis of a nominal value for each of said resistances, each of a plurality of said elements having an actual value differing from its nominal value, but the true value of a series group of said elements varying from the sum of nominal values of the elements constituting said group by an amount less than the greatest individual variation among the elements of the group.

16. An electrical device comprising impedance elements in series, said device being calibrated on the basis of a nominal value for each of said elements, each of a plurality of said elements having an actual value differing from its nominal value, but the actual value of a series group of said elements varying from the sum of the nominal values of the elements constituting said group by an amount less than the greatest individual variation among the elements of the group.

17. In combination, a vacuum tube repeater having cathode and control electrodes, a transformer having its secondary connected in series with the space between said electrodes, a condenser forming with the inductance presented by the primary of said transformer a series tuned circuit and a resistance in parallel with said condenser, said condenser and said inductance resonating at a frequency to be repeated.

18. In combination, a vacuum tube repeater having cathode and control electrodes, a transformer having its secondary connected in series with the space between said electrodes, a condenser forming with the inductance presented by the primary of said

transformer a series tuned circuit, a resistance in parallel with said condenser, and an inductance in series with said parallel arrangement, said last mentioned inductance forming with the capacity between the transformer windings and said electrodes a circuit which is resonant at frequencies for which the impedance of said condenser is negligible.

19. In combination, a transformer presenting in its primary circuit an inductive reactance at low frequencies and a capacity reactance at relatively high frequencies, a condenser and a resistance in parallel forming with said inductive reactance a circuit tuned to a relatively low frequency, and an inductance forming with said capacity reactance a circuit tuned to a relatively high frequency.

20. In combination, a transformer presenting in its primary circuit an inductive reactance at low frequencies and a capacity reactance at relatively high frequencies, a condenser and a resistance in parallel forming with said inductive reactance a circuit tuned to a relatively low frequency, and an inductance forming with said capacity reactance a circuit tuned to a relatively high frequency, the primary of said transformer, said inductance and said parallel arrangement being connected in series.

21. In combination, a transformer presenting in its primary circuit an inductive reactance at low frequencies and a capacity reactance at relatively high frequencies, a condenser and a resistance in parallel forming with said inductive reactance a circuit tuned to a relatively low frequency, and an inductance forming with said capacity reactance a circuit tuned to a relatively high frequency, and a second resistance for damping said tuned circuits, the primary of said transformer, said inductance, said second resistance and said parallel arrangement being connected in series.

22. In combination, a vacuum tube repeater, an input transformer therefor, means resonating with the inductance and capacity of said transformer respectively, and a potentiometer adjustably connected to said transformer, said potentiometer being so arranged that at all settings a substantially constant impedance is connected between the terminals of said transformer.

23. In combination, a vacuum tube repeater having cathode and control electrodes, a transformer having higher transmission efficiency in the middle than in the lower portion of the voice frequency range and having its secondary connected in series with the space between said electrodes, the primary of said transformer presenting an inductive reactance at a frequency in the lower part of the voice range, and a condenser and a resistance in parallel connected in series with said primary, said condenser being of such capacity as to tune with said inductive reactance at said frequency in the lower part of the voice range, and said resistance being of such value as to maintain the repeater gain at said resonance frequency substantially the same as in the middle portion of the voice range.

24. An attenuation network having terminals for connection to a source of electromotive force and terminals for connection to a receiving circuit, and adjusting means for varying the potential across the second mentioned terminals for a given potential applied to said first mentioned terminals while maintaining substantially constantly impedances as seen looking into both the first mentioned terminals and the second mentioned terminals from without the net-work.

25. The method of operating a potentiometer having input terminals and a receiving circuit fed from said potentiometer which comprises altering the connection of the circuit to the potentiometer to impress different electromotive forces upon the circuit for a given electromotive force across said input terminals, and maintaining the impedance of the potentiometer facing the circuit the same for the different connections.

In witness whereof, I hereunto subscribe my name this 24th day of August A. D. 1920.

DONALD FAIRFAX WHITING.