

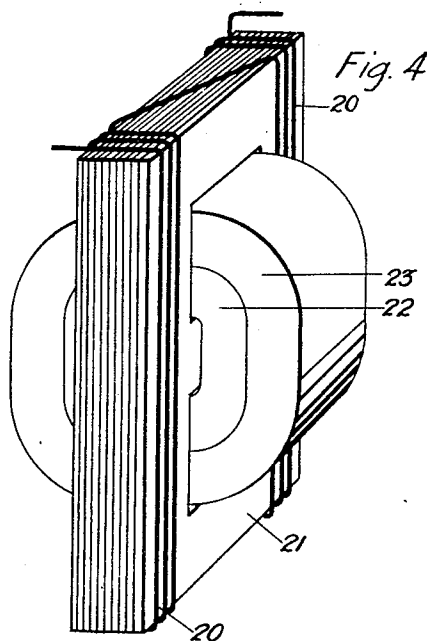
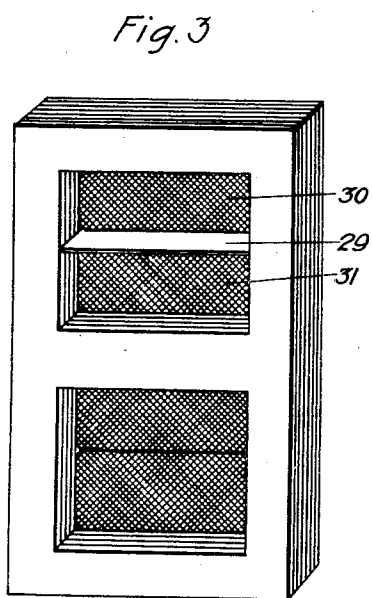
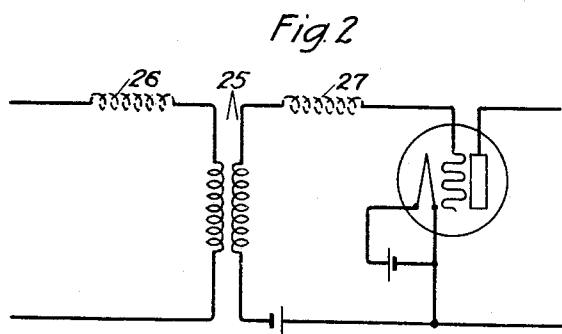
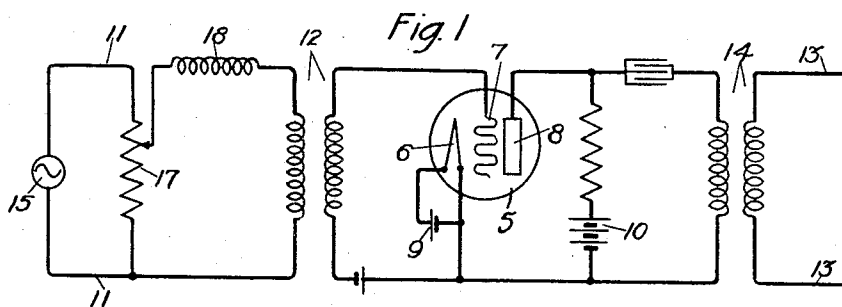
March 24, 1925.

1,530,648

W. L. CASPER

ELECTRIC CIRCUITS

Filed March 17, 1920



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UNITED STATES PATENT OFFICE.

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ELECTRIC CIRCUITS.

Application filed March 17, 1920. Serial No. 366,581.

To all whom it may concern:

Be it known that I, WILLIAM L. CASPER, a citizen of the United States, residing at Brooklyn, in the county of Kings, State of New York, have invented certain new and useful Improvements in Electric Circuits, of which the following is a full, clear, concise, and exact description.

This invention relates to electric circuits and more particularly it relates to methods and means for reducing the distortion in a repeating system.

As is well known in the art, weak currents or signals may be amplified to any desired degree by impressing them on one or more vacuum tube amplifiers arranged to work into each other by suitable circuit connections. In employing the vacuum tube as an amplifier it has been found that the tube works most efficiently when the impedance between the control electrode and the cathode is composed substantially of resistance with no capacity component. In that form of a vacuum tube wherein the control electrode or grid is within the tube and adjacent to the cathode there is present a certain amount of capacity between the cathode and the grid, dependent in value upon the size of the electrodes and the distance therebetween. This capacity effect is generally negligibly small for currents of low frequency but if the frequencies impressed on the tube are relatively high the capacity effect may be quite appreciable and cause a certain amount of distortion in the current waves to be repeated. It has also been found in the case where the vacuum tube repeater is connected to the incoming line by means of a transformer that further distortion and a lowering of the efficiency of the repeater takes place, which distortion is due to capacity effects between the turns of the windings of the transformer.

In accordance with this invention, the undesired grid-cathode capacity and the transformer capacity may be neutralized by including in series with these capacities an inductance of such value as to be resonant therewith for the frequency or band of frequencies which are of the most importance in the impressed currents. With such an arrangement, the grid capacity and the transformer capacity will be neutralized, which is the result desired.

This invention will be better understood

by reference to the following detailed description taken in connection with the accompanying drawings in which Fig. 1 represents an embodiment of this invention; Fig. 2 is a modification thereof; Fig. 3 illustrates how a transformer may be made to have an inefficient coupling for the purpose of this invention; and Fig. 4 illustrates how the additional inductance for neutralizing the undesired capacities may be wound on the core of the transformer in which the undesired capacity is present.

Referring to Fig. 1, 5 is a vacuum tube amplifier having a cathode 6, a grid 7 and an anode 8. Heating current for cathode 6 is supplied by a battery 9. Space current for the tube is supplied from a source of voltage 10. The input electrodes 6 and 7 of the tube are connected to an incoming line 11, 11 by means of a transformer 12. The amount of potential impressed on the tube 5 by line 11, 11 is determined by the value of potentiometer 17. The output electrodes 8 and 6 of the tube are connected to an outgoing line 13, 13 by means of a transformer 14. With such an arrangement tube 5 is adapted to amplify currents impressed on line 11, 11 by source 15, the amplified currents being impressed on line 13, 13 by transformer 14.

It has been found even where the frequency of the incoming current is as low as 1,000 cycles, that the impedance between grid 7 and cathode 6 consists not only of a resistance component but has an appreciable capacity component. This capacity component produces distortion in the repeated signals and is, therefore, undesirable particularly for ultra-audio frequencies where the effect is most marked. It has also been found that there is a lowering of the efficiency of the system due to the capacity effect present between the windings of input transformer 12. In accordance with this invention the undesired grid capacity and the transformer capacity are substantially eliminated by inserting, in series with the primary winding of transformer 12, an inductance 18 of such a value as to be resonant with these capacities for the frequency of source 15. In case source 15 supplies a plurality of frequencies, resonance should occur for that frequency or band of frequencies which is of the most importance. This inductance 18 therefore serves to neutralize

the transformer capacity and also causes the impedance between grid 7 and cathode 6 to be of substantially pure resistance in character, thereby improving to a considerable degree the quality of the transmission between lines 11 and 13.

In the circuit arrangement of this invention wherein it is desired to employ, in connection with this invention, a potentiometer for adjusting the amount of potential applied to the vacuum tube from the incoming line, it has been found more satisfactory, as shown in Fig. 1, to have the potentiometer connected to the primary of the input transformer instead of the secondary winding as has hitherto been customary in the art.

As an example of the value inductance 18 may have it was found that with a vacuum tube having an effective capacity of 75 microfarads between its input electrodes for a frequency of 2000 cycles and with a transformer having a ratio of 1 to 40 and with a capacity between its turns of 25 micromicrofarads for the same frequency, inductance 18 should be approximately 3 millihenrys.

It is not necessary that the correcting inductance be a separate element of the circuit. Fig. 4 shows how additional turns 20 may be wound around the core 21 of a transformer so as to have little or no mutual inductance with the primary and secondary windings 22 and 23 of the transformer. These turns 20 should be electrically connected in series with the primary winding of the transformer so that the device of Fig. 4 is the full equivalent of elements 12 and 18 of Fig. 1.

Fig. 2 is a modification of Fig. 1 in that for transformer 12 of Fig. 1, a transformer 25 has been substituted which has an inefficient coupling. A transformer with an inefficient coupling is equivalent to a transformer of perfect coupling with an inductance element in series with the primary and secondary windings. If now the coupling of transformer 25 is made inefficient to such a degree that the equivalent inductances 26 and 27, in circuit with its primary and secondary windings, are of such values as to be resonant with the transformer capacity and the grid capacity for the frequencies of importance in the incoming currents, it follows that these capacities will be neutralized in a manner similar to that in the system shown in Fig. 1.

One way in which the coupling of a transformer may be made inefficient, is shown in Fig. 3 where a sheet 29 of magnetic material has been placed between the primary and secondary windings 30 and 31 of a transformer. This sheet 29 will serve as a by-path for some of the lines of force between the primary and secondary windings thereby making the transformer inefficient. By regulating the size of this element 29, it will

be possible to produce the desired degree of inefficient coupling in the transformer, which is necessary to give the equivalent inductance for neutralizing the grid and transformer capacities for the frequencies to be transmitted by the vacuum tube circuit. It is obvious that the coupling in a transformer may be made inefficient in other ways than the method just described.

What is claimed is:

1. In a wave transmitting circuit for simultaneously transmitting a band of frequencies, a transformer having a greater transmission efficiency for certain of the frequencies in said band than for others, said transformer possessing a capacitative reactance component, and means for rendering the transmission efficiency of said transformer more nearly uniform for all the frequencies in said simultaneously transmitted band, comprising inductance separate from and in addition to the transformer for cooperating with the capacitative reactance component of the transformer to improve the efficiency for those frequencies at which the transformer alone has relatively low efficiency.

2. In a wave amplifying circuit for amplifying a band of frequencies, an amplifier and a transformer in tandem relation, said amplifier and transformer having a greater transmission efficiency for certain of the frequencies in said band than for other frequencies of said band, and said transformer and amplifier possessing a capacitative reactance component, and means for rendering the transmission efficiency of said transformer and amplifier more nearly uniform for all the frequencies in said band, comprising an inductance in said circuit and separate from and in addition to said transformer and amplifier for cooperating with the capacitative reactance component of said transformer and amplifier to improve the efficiency for those frequencies at which the transformer and amplifier alone have relatively low efficiency while still permitting the efficient transmission of those frequencies of the band for which the system without said inductance has high transmission efficiency.

3. In a wave amplifying circuit for simultaneously amplifying a band of frequencies, an amplifier and a transformer in tandem relation, said amplifier and transformer having a greater transmission efficiency for certain of the frequencies in said band than for other frequencies in said band, and said transformer and amplifier comprising reactance, and means comprising inductance separate from and in addition to the reactance of the transformer and amplifier for so resonating with the reactance of the transformer and amplifier as to increase the efficiency, at those frequencies at which the

transformer and amplifier alone have relatively low efficiency, to such a value that the width of the band of frequencies which are simultaneously transmitted with equal efficiency is increased.

4. In a wave amplifying circuit for amplifying a band of speech frequencies, an electric discharge amplifier having an anode, a cathode, and a control electrode, a transformer having a primary winding and having a secondary winding connected to said cathode and control electrode, an appreciable capacity effect existing between the turns of said windings, said amplifier having an appreciable capacity effect between said cathode and control electrode and said capacity effects tending to cause certain frequencies of said band to be transmitted more efficiently than other frequencies of said band, and an inductance element separate from and in addition to said transformer and amplifier and acting effectively in series in the line of propagation of said waves for so resonating with said capacity effects as to increase the efficiency, simultaneously at those frequencies at which the transformer and amplifier alone have relatively low efficiency, to such a value that the width of the band of frequencies which said circuit is capable of transmitting simultaneously with equal efficiency is increased.

5. In a wave amplifying system for amplifying a band of frequencies, an amplifier, an input transformer feeding said amplifier, said transformer having a capacity effect between the turns of its windings, said amplifier having input terminals between which an appreciable capacity effect exists, and said capacity effects acting as a shunt across the line of propagation of said waves to cause certain of the frequencies of said band to be transmitted with less efficiency than other frequencies of said band, and an inductance separate from and in addition to said transformer and amplifier and connected effectively in series in the line of propagation of said waves, which inductance, while permitting the system to transmit with substantially the same efficiency those frequencies of the band for which it has greater transmission efficiencies, and with the same adjustment of the system, resonates with said capacity effects to increase the efficiency at those frequencies at which the transformer and amplifier alone have relatively low efficiency, to such a value that the width of the band of frequencies which said system is capable of transmitting with equal efficiency is increased.

In witness whereof, I hereunto subscribe my name this 15th day of March, A. D. 1920.

WILLIAM L. CASPER.