

July 7, 1931.

G. A. SOMERSALO

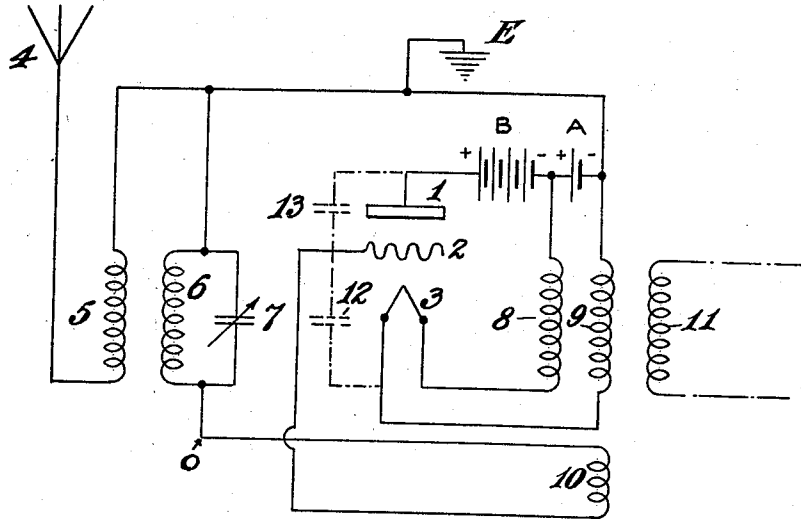
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MEANS FOR PREVENTING RETROACTIVE EFFECTS IN AUDION AMPLIFIER CIRCUITS

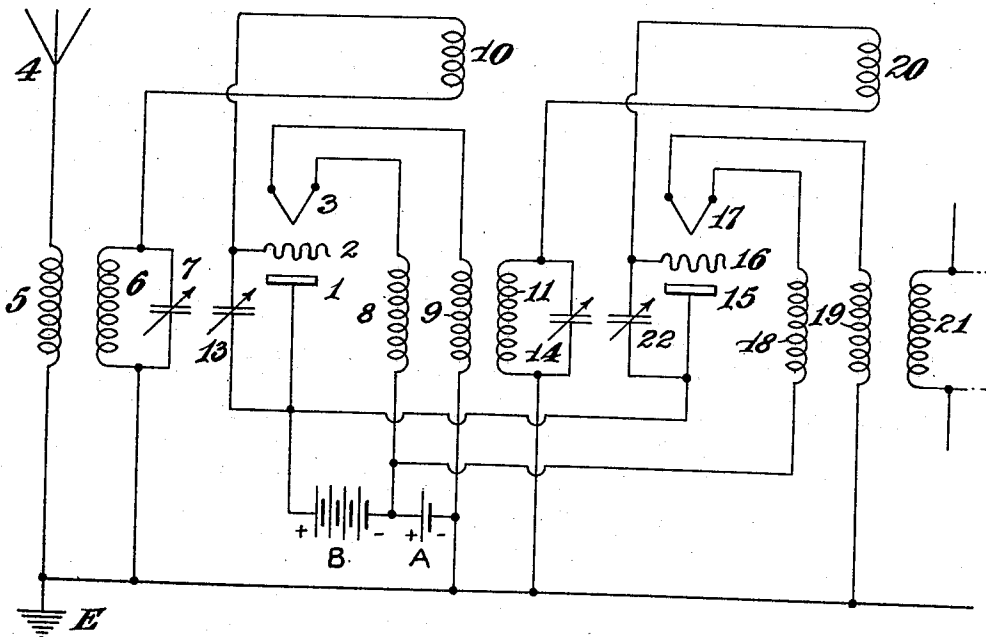
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*Fig. 1.*



*Fig. 2.*



INVENTOR  
GEORGE A. SOMERSALO  
BY  
*Strom and Strom*  
ATTORNEYS

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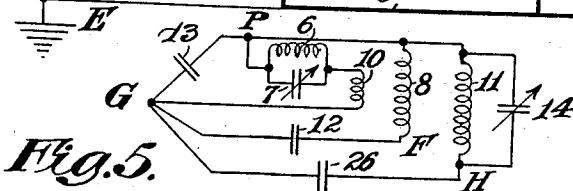
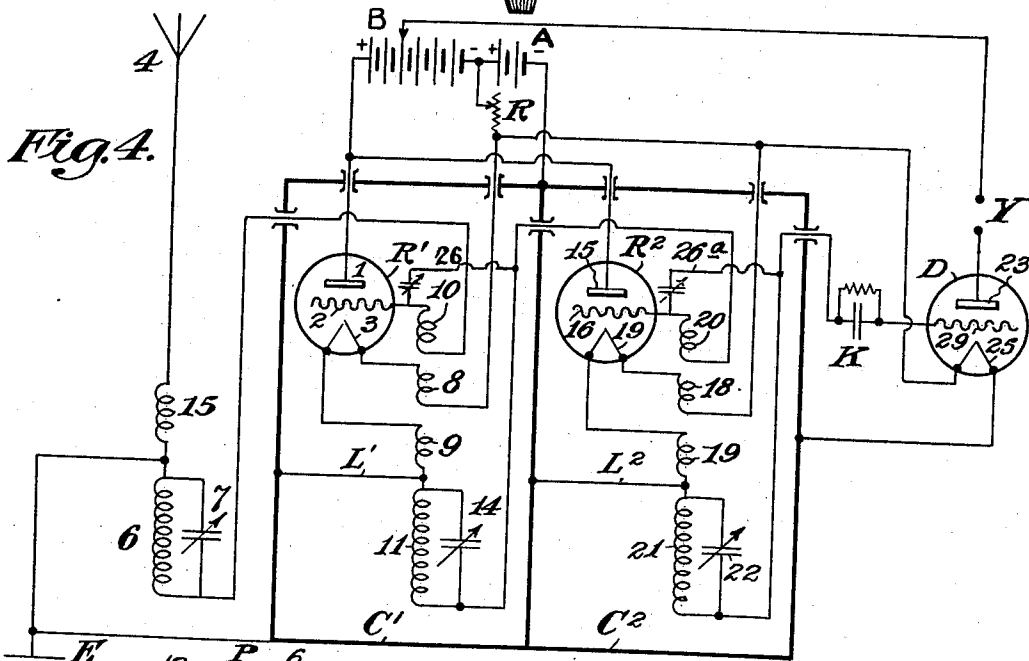
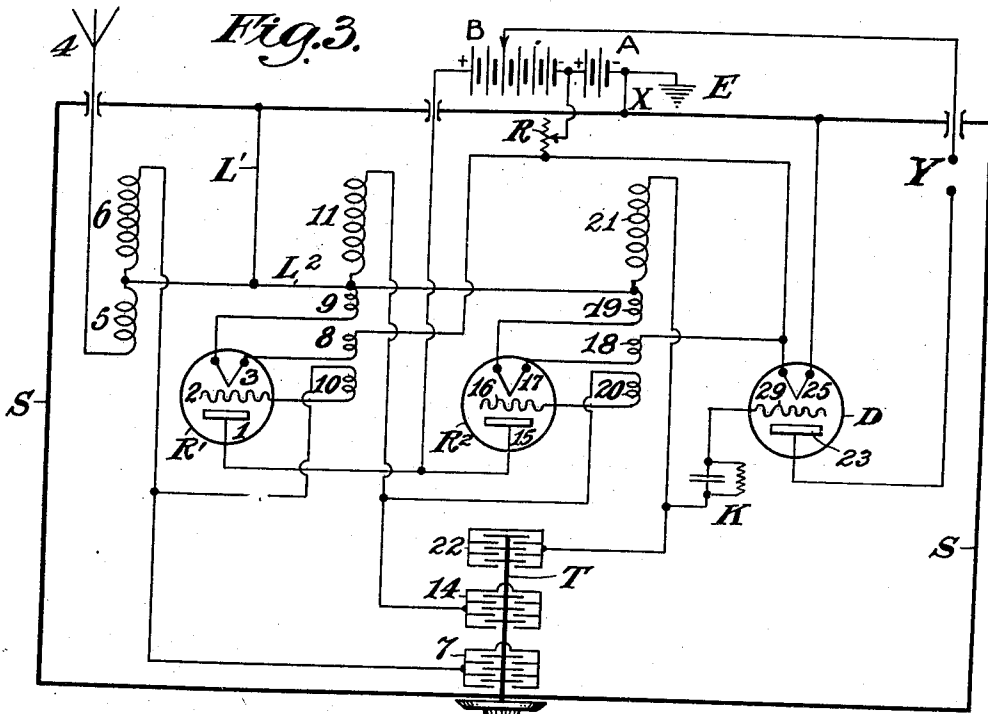
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2 Sheets-Sheet 2



INVENTOR  
GEORGE A. SOMERSALO  
BY  
*Johnson & Johnson*  
ATTORNEYS

## UNITED STATES PATENT OFFICE

GEORGE A. SOMERSALO, OF NEW YORK, N. Y.

MEANS FOR PREVENTING RETROACTIVE EFFECTS IN AUDION AMPLIFIER CIRCUITS

Application filed January 27, 1927. Serial No. 164,099.

This invention relates to the amplification of electric currents of minute intensities such as experienced in the reception of radio telephonic and telegraphic signals by means of audion tubes of the three-electrode type, and more particularly to the provision of means for neutralizing, balancing, or otherwise compensating for the inherent capacity coupling between the input and output electrodes of the audion tubes of the amplifier.

It has long been known that when audion tubes are energized and the filament and grid electrodes connected to a source of alternating signal energy, and the filament and plate electrodes connected to a suitable output circuit, that the variations in the output circuit are fed back into the input circuit, due to the inherent capacity coupling existing between the electrodes contained in the input and output circuits. These current variations fed back into the input circuit may, and frequently do, cause oscillations which, in amplifiers, are particularly objectionable since they interfere considerably with the reception of the incoming signals and frequently rise to such magnitudes as to completely incapacitate the amplifier.

In my copending application, Ser. No. 18,019, filed March 24, 1925, I have secured the desired balance or neutralization between the input and output circuits by means of a network which includes inductances in the input and output circuits, and a connection between one end of the input inductance and a point intermediate the ends of the output inductance, the point of connection on the output inductance being predetermined to establish a ratio between the turns on opposite sides of said point of connection equal to the inverse ratio between the inherent capacity couplings of the audion tube electrodes.

In my Patent No. 1,633,421, dated June 21, 1927, I have shown that the same results may be obtained by a different form of network wherein a direct connection is made between the low potential end of the input inductance and the plate electrode through a suitable blocking condenser, and including in this connection an inductance which is inductively coupled to the output inductance

between the plate and filament. This inductive coupling is designed so that the mutual inductance thereof has a certain definite relation to the ratio of the inherent capacity couplings between the tube electrodes.

In applying either of these circuit arrangements to actual practice, and particularly to commercial apparatus, it has been found that for complete neutralization of the retroaction or feed back of the output voltage upon the input circuit for substantially all frequencies, consideration must be given not only to the coupling due to the inherent capacities of the tubes, but also to such electro-magnetic and electro-static couplings which may exist between the several elements of the circuits, and which would prevent perfectly balanced or stabilized reception. The undesirable effects of external electro-magnetic and electro-static couplings of this nature are generally destroyed, either by shielding the several stages of the apparatus or by grounding the rotors of the tuning condensers of the several stages, and while either of these expedients is highly effective, the latter is by far the most desirable, since it renders possible the mounting of the tuning condensers of the several stages on a single shaft, thereby providing a unitary or single dial control for the set.

However, it will be noted that with the circuits arranged as shown and described in my two pending applications above noted, the condenser rotors cannot be conveniently grounded without short circuiting certain elements of the circuits. For instance, in the scheme shown in my Patent No. 1,633,421, if the rotors were grounded and the filaments connected in parallel, using a common A-battery, the output coils in respective stages would all be connected in shunt, causing a violent feed-back, which would prevent all reception.

One object of the present invention therefore is to re-arrange the elements of the network of my prior applications so that, while still preserving a balanced condition between the input and output circuits, I can mount the several tuning condensers on a single grounded shaft, and thereby simul-

taneously destroy the electro-static and electro-magnetic couplings between elements of the circuit and provide a balanced, stabilized receiving set having a single dial control.

5 Another object of the invention is to provide an improved and novel manner of connecting audion amplifiers in cascade, which includes grounding the plate electrodes instead of the filaments, through the B-battery and thus rendering the filament in effect, the  
10 alternating current high voltage side of the audion, that is, the alternating current potential of the plate will be zero, while that of the filament will have increasing values for  
15 consecutive stages.

These and other objects of the invention will become apparent from the following specification, taken in connection with the accompanying drawings, wherein

20 Fig. 1 is a single stage amplifier constructed in accordance with the present invention;

Fig. 2 is the circuit arrangement for a multiple stage amplifier, two stages being shown connected in cascade;

25 Fig. 3 shows a commercial receiver using the circuit arrangement of Fig. 2, and including two stages of tuned radio frequency amplification and a tuned detector;

30 Fig. 4 shows a modified form of the circuits shown in Figs. 2 and 3; and

Fig. 5 shows a double bridge system of balancing incorporated in the circuit of Fig. 4.

35 Referring more particularly to Fig. 1 of the accompanying drawings, the audion electrodes plate, grid and filament are numbered 1, 2 and 3 respectively. The antenna circuit including the antenna 4, the coil 5 and the ground E, is inductively coupled to a resonant or tuned input circuit comprising coil 6  
40 and variable condenser 7, the latter being connected in shunt relation with coil 6, in the usual manner. The resonant or tuned input circuit is connected on one side to the  
45 plate 1, through A and B batteries, and on the other side to the grid 2, said last mentioned connection including a balancing inductance 10, to be referred to more particularly hereinafter.

50 The plate 1 is also connected to the filament 3, through the B-battery and an output coil or inductance 8. The filament 3 is energized, in the usual manner, from the A-battery, it being noted however, that the connection thereto includes an inductance 9, inductively coupled with the inductances 8 and  
55 10, and that the connection to the A-battery also makes contact or connection with resonant input circuit 6-7.

60 The batteries A and B are connected next to the plate and are shown grounded through the negative A terminal. It is to be understood, however, that the batteries could just as well be grounded through the positive A  
65 terminal, and also that where the term

"ground" is used, it is not to be construed as meaning actual ground only, but may include such parts of the set which have strong electro-static coupling with the actual ground, such as for instance shields, metallic cabinets, etc. 70

The neutralization of retro-action or feedback in this circuit is accomplished by the joint action of the balancing coil 10 and the capacities 12 and 13, between the filament  
75 and grid, and the grid and plate respectively.

The capacities 12 and 13 may be either the inherent capacity couplings of the tube electrodes, or they may be external capacities similarly connected; or one of them may be  
80 an external capacity and the other an inherent internal capacity, which latter arrangement is preferred as shown in Fig. 2. In either arrangement they constitute elements  
85 of my balancing network wherein the voltage of the output circuit between plate and grid is prevented from affecting the tuned input circuit, in the following manner:

90 Considering the alternating current output voltage impressed upon the output coils 8 and 9 and its retro-active effect upon the input coil 6, it will be seen that one terminal of this input coil, that next to the plate, has obviously the same alternating current potential as that of the plate, the potential drop through  
95 the batteries being practically negligible. The output coils 8 and 9 will now have such an inductive effect upon the balancing coil 10 that the other terminal marked 0 in Fig. 1, of the input coil will also have the same potential as the plate. Consequently, with respect to the retro-active effect of the output  
100 voltage the terminals of the input coil 6 are at the same potential, and hence there can be no feed-back from output to the input. The sense of winding of the balancing coil must be right, otherwise it would cause regeneration instead of preventing feed-back.

105 In Fig. 2 I have shown a two-stage amplifier, comprising two stages, similar to that shown in Fig. 1, and interconnected in cascade. It will be noted that the coil 11 of the tuned or resonant input circuit of the second stage is inductively coupled to the coils 8,  
110 9 and 10 of the first stage. The plate, grid and filament of the second stage audion, are indicated by the numerals 15, 16 and 17 respectively, and are interconnected in the same manner as the electrodes of the first stage, it being noted, however, that the plate electrodes of the two stages, numbered 1 and 15,  
115 are directly connected together and grounded through the batteries. Also the filament circuit of the second stage is connected to the A-battery in parallel with the filament circuit of the first stage, while the tuning condensers 7 and 14 are both grounded through  
120 the common ground E. In this arrangement the balancing is accomplished by the action of the balancing coils 10 and 20 with the con- 130

condensers 13 and 22 respectively, in the manner described in connection with the description of Fig. 1.

In Fig. 3 I have shown a practical arrangement of the circuit shown in Fig. 2, designed for use as a commercial receiver comprising two tuned stages of radio frequency amplification, and a tuned detector. The amplifier audions are indicated at  $R^1$  and  $R^2$ , and the detector audion by D. The entire apparatus with the exception of the antenna and batteries are enclosed within a metallic or shielded cabinet indicated by the letter S, which is preferably connected to the antenna ground E, as shown at X. The antenna 4 is inductively coupled to the tuned or resonant input circuit of the first stage by coils 5 and 6, the latter being shunted by the tuning condenser 7, it being noted that the input coils 11 and 21 of the second stage and detector respectively are correspondingly shunted by the tuning condensers 14 and 22 which together with condenser 7, are mounted on a single shaft T, journaled in the shield S, and may be simultaneously operated by a suitable dial. Hence the rotors of the three condensers are grounded through the shaft and shield, and through the shield they are also in electrical connection with the terminals of the coils 6, 11 and 21 by means of the leads  $L^1$  and  $L^2$ . These grounded terminals may thus be considered as the alternating current, low potential side of the transformer secondaries. The primary windings of the inter-stage transformers are indicated by the numerals 8, 9 and 18, 19, respectively, while the balancing coils bear the numerals 10 and 20. In order to avoid stray capacities the balancing coils, as shown, are preferably placed on the low potential side of the secondary windings, and are arranged so that their sense of the winding tends to counteract the retro-action or feed-back. The plate electrodes of the amplifier tubes  $R^1$  and  $R^2$  are directly connected together and grounded through the batteries, while the plate of the detector tube is connected through a pair of output terminals Y to an intermediate point on the B-battery whereby to supply the detector plate circuit with the usual reduced potential. The filaments of the several tubes are connected in parallel to the A-battery through a variable resistance R, and the grid circuit of the detector includes the usual grid leak condenser and resistance unit K. The output terminals Y may be connected to a telephone receiver, or to the input terminals of an audio frequency amplifier, as desired.

In Fig. 4 a modified circuit arrangement is shown similar to that of Figs. 2 and 3, and comprising two radio frequency amplifier stages and a detector. The radio frequency stages are enclosed in shielded compartments  $C^1$ ,  $C^2$ . These shielded units are designed so that all the elements which may affect the

neutralization of any one tube are enclosed in the same shielded compartment. Consequently each unit can be separately neutralized, and when carefully neutralized, any number of such units may be connected in cascade. The simplicity of this arrangement is shown by the fact, that in addition to the battery wires, only one wire is required to connect one unit with the next one. Here too the rotors are grounded through the leads  $L^1$  and  $L^2$ . The elements which are left outside the shielded units comprising the aerial transformer, detector and audio frequency amplifiers, may be enclosed in a common shield, if desired. This system, by neutralized shielded units, provides a very superior method for building a high power receiving set.

It may be added that in all of the networks shown in Figs. 1 to 4 inclusive, a certain disturbance of the balancing may result from the reaction of the secondary coil upon the balancing coil. This disturbance, if it exists, may be readily rectified by manipulation of the condenser 13 (Fig. 2) which may be employed in any of the networks. It may be simpler, however, to insert another balancing condenser to take care of this particular disturbance—introducing it in the connection between the grid and the high voltage end of the secondary coil. I have illustrated this at 26 and 26<sup>a</sup> in Fig. 4. In effect this constitutes a balancing bridge for the secondary circuit similar to the balancing bridge for the primary circuit. This has an advantage from the practical standpoint since I have found that a complete balance may be more readily effected, by balancing the secondary circuit independently of the primary circuit. The diagrammatic illustration of this method in Fig. 5 makes the operation clear. In this figure P represents the plate; G, the grid; F, for filament, and H, the high voltage side of the secondary coil 11.

In conclusion it will be seen that I have provided a novel arrangement of cascade connection for multiple stage amplifiers in which provision is made for neutralizing or balancing the retro-action or feed back actions of the output voltage upon the input circuit, the arrangement being such that electro-static couplings between certain elements of the receiving set may be destroyed by grounding the rotors of the tuning condensers without in any way affecting the neutralizing action of the circuit, the result being that I am able to provide a completely neutralized and stabilized receiver having a single dial or unitary control. While I have here chosen to illustrate and describe certain preferred embodiments of my invention, it is to be understood that such illustrations and description are for the purpose of example only and not as defining the limits of my invention, which

are to be determined from the scope of the appended claims.

What I claim is—

1. The method of controlling or eliminating the effect of a disturbing electro-motive force in the plate filament circuit of a three-element thermionic device upon the input element associated with the grid and plate of said thermionic device, which comprises establishing a point which due to said disturbing electro-motive force assumes the potential of the plate, and impressing the input energy through said input element between said point and the plate. 70
  2. An audion receiving network comprising a plate filament circuit including an output inductance and a source of direct current energy, said source being connected next to the plate, and an input circuit between grid and plate including an inductance inductively coupled to the inductance in the plate-filament circuit thereby preventing retro-action of the output voltage upon the input circuit. 75
  3. An audion receiving network comprising a plate filament circuit including an output inductance and a source of direct current energy, said source being connected next to the plate, an input circuit between grid and plate, and means for preventing retro-action of the output voltage upon the input circuit including a second inductance inductively coupled to the inductances in the plate filament circuit. 80
  4. An audion receiving network comprising a plate filament circuit including an output inductance and a source of direct current energy, said source being connected next to the plate, an input circuit between grid and plate, and means for preventing retro-action of the output voltage upon the input circuit including a second inductance inductively coupled to the inductances in the plate filament circuit, said second inductance being a part of the input circuit. 85
  5. An audion receiving network comprising a plate filament circuit including an output inductance and a source of direct current energy, said source being connected next to the plate, an input circuit between grid and plate, and means for preventing retro-action of the output voltage upon the input circuit including a second inductance inductively coupled to the inductances in the plate filament circuit, and an external condenser connected between the grid and one of the other electrodes. 90
  6. An audion receiving network comprising a plate filament circuit including an output inductance and a source of direct current energy, said source being connected next to the plate, an input circuit between grid and plate, and means for preventing retro-action of the output voltage upon the input circuit including a second inductance inductively coupled to the inductances in the plate filament circuit, and a substantially capacitive impedance connected between the grid and one of the other electrodes. 95
  7. An audion receiving network comprising a plate filament circuit including an output inductance and a source of direct current energy, an input element between grid and plate, and means for preventing retro-action of the output voltage upon the input element including a second inductance inductively coupled to the output inductance, said second inductance being situated between the grid and the input element, and an external condenser connected between the grid and one of the other electrodes. 100
  8. In a multistage audion amplifier, each stage of which includes a tuned input circuit containing a variable condenser, a grounded shield enclosing said amplifier, the alternating current potential of the plates being substantially that of the shield, and a shaft rotatably mounted in the shield, the rotors of the variable condensers of the several stages being mounted on said shaft for simultaneous adjustment with respect to their stators. 105
- In testimony whereof I have signed my name to this specification.
- GEORGE A. SOMERSALO. 110