July 30, 1946. W. J. O'BRIEN 2,404,809

COMPENSATING CIRCUIT

Filed Aug. 5, 1941

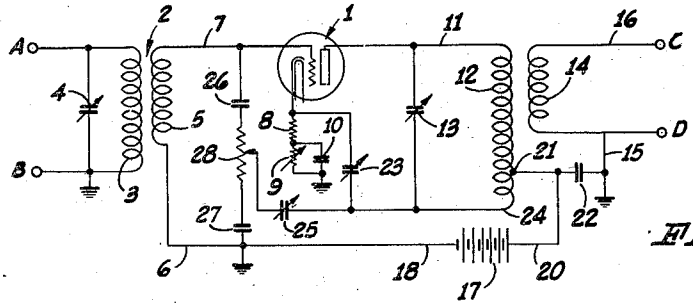

FIG. 1.

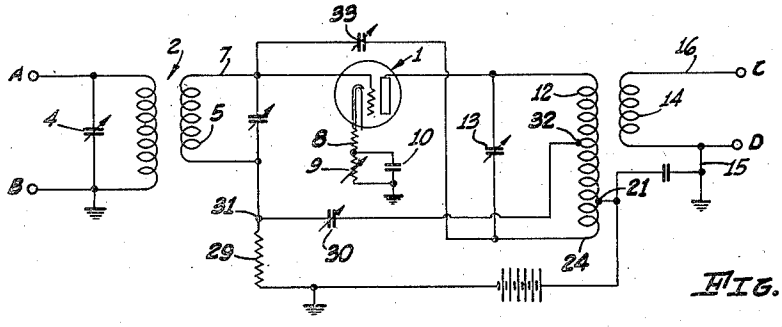

FIG. 2.

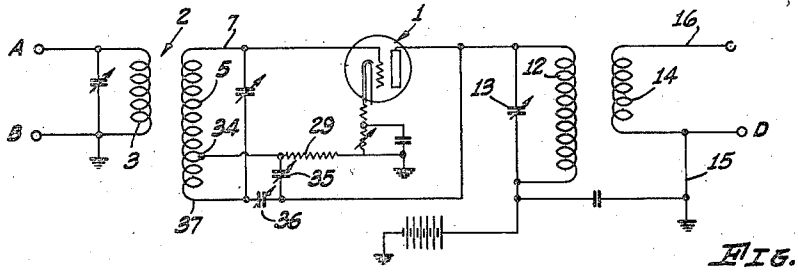

FIG. 3.

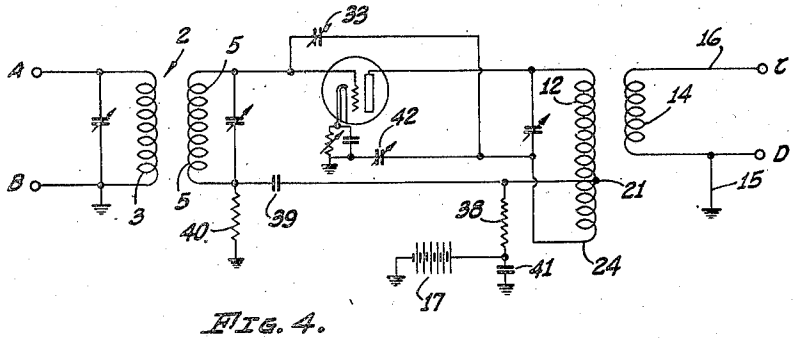

FIG. 4.

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COMPENSATING CIRCUIT

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13 Claims. (Cl. 179—171)

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My invention relates to thermionic amplifiers and has particular reference to an alternating voltage amplifier circuit including means for neutralizing or compensating for changes in the internal capacities of a thermionic amplifier tube to prevent those changes from affecting the phase relation between the in-put and out-put voltages of the amplifier.

In certain thermionic alternating voltage amplifier applications it is desirable to maintain a fixed phase relation between the in-put and out-put potentials of the amplifiers, and it is also often necessary to vary the grid bias on the thermionic tubes of such amplifiers for the purpose of varying the amplification of such tubes; for example, as by means of automatic volume control circuits. It has been discovered that the change in space charge due to changing the grid bias of the tube causes a change in the effective grid to cathode or grid to space charge capacity of the tube and this change produces a corresponding change in the phase relationship between the in-put and out-put voltages of the amplifier.

Attempts have been made prior to my invention to neutralize or compensate for this changing in-put capacity of the tube, but these attempts have not been directed to maintaining a constant phase relationship between the in-put and out-put voltages. As a result, the neutralizing means employed prior to my invention while compensating for the changing in-put capacity of the tube affected also the out-put circuit of the tube so as to cause a shift in phase of the out-put potential with respect to the in-put potential.

The present invention is directed to a means for neutralizing or compensating for the effects of the grid circuit neutralizing means on the out-put circuit of the tube and is also directed to a circuit including means for neutralizing or compensating for the changes in the in-put capacity of the tube, the out-put capacity of the tube and the grid to plate capacity of the tube.

It is, therefore, an object of my invention to provide a thermionic amplifier circuit which includes a means for maintaining a fixed phase relationship between the in-put and out-put voltages of the thermionic tube irrespective of changes in grid bias.

It is also an object of my invention to provide an amplifier circuit of the character set forth in the preceding paragraph which includes a means for neutralizing the effect of changes in the in-put capacity of the tube and a means for

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compensating for the effect of the neutralizing means on the out-put circuit of the tube.

It is a still further object of my invention to provide a thermionic circuit of the character set forth in the preceding paragraphs which includes a compensating means for reducing the grid to cathode voltage in accordance with increases in the grid to cathode capacity of the tube.

It is additionally an object of my invention to provide an amplifier circuit of the character set forth in the preceding paragraph in which the compensating means is included in that portion of the circuit which is common to both the grid and plate circuits of the tube, and which includes also neutralizing means for preventing a phase shift in the out-put voltage resulting from reactive current flowing in said portion of the circuit through the plate to cathode capacity of the tube.

Other objects and advantages of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawing, wherein:

Fig. 1 is a circuit diagram illustrating the preferred embodiment of my invention; and

Figs. 2, 3 and 4 are each circuit diagrams illustrating modified forms of the invention.

Referring to the drawing, I have illustrated in Fig. 1 a thermionic alternating voltage amplifier circuit as including a thermionic amplifier tube or vacuum tube 1 of conventional construction including at least a cathode or electron emitter, an anode or plate, and a control electrode or grid. For the purpose of simplifying the illustration and the description, a conventional three element tube has been shown. It will be appreciated, however, that the same problems arise and the same considerations also apply to the multi-element tubes such as the tetrodes, pentodes, and the like. The in-put circuit of the amplifier may include a coupling unit such as an in-put transformer 2, the primary 3 of which may be tuned as by means of a variable condenser 4, voltages to be amplified by the amplifier being applied across the primary winding 3 as between terminals A and B. The secondary winding 5 of the transformer 2 has one terminal grounded as by means of a conductor 6 and has the other terminal connected to the grid of the tube 1 as by means of a conductor 7.

The cathode of the tube 1 is connected to ground to complete the in-put circuit through a fixed compensating resistance 8 and a grid bias resistance 9 which is preferably shunted with a by-pass condenser 10. I have illustrated the resistor 9 as being variable to indicate one way in

which the grid bias or negative potential which is applied to the grid of the tube may be changed, it being understood, of course, that the resistor 9 may be omitted if desired and a variable grid bias applied to the tube in other conventional ways.

The out-put circuit of the tube may include a conductor 11 extending from the plate of the tube to an out-put coupling device such as a transformer including a primary winding 12, which winding may be connected in parallel with a tuning condenser 13 if desired. The secondary winding 14 of the out-put transformer has one terminal grounded as by means of a conductor 15 and the other terminal connected as by means of a conductor 16 to out-put voltage terminals C and D.

Positive plate potential may be supplied by means of a battery 17 or equivalent source, the negative terminal of the battery 17 being grounded as by means of a conductor 18 and the positive terminal being connected as by means of a conductor 20 to a tap 21 on the primary winding 12. The conductor 20 may be maintained at ground potential with respect to alternating current in the plate circuit as by connecting a by-pass condenser 22 between the conductor 20 and ground.

As has been pointed out hereinbefore, the vacuum tube 1 includes an internal capacity in its in-put circuit which capacity results from the proximity of the grid to the space charge produced by the electronic emission of the cathode. The effect of this capacity on the in-put circuit is the same as if a small condenser were connected in a metallic circuit between the grid terminal and the cathode terminal of the tube.

The space charge of the tube changes with changes in grid bias and so produces a corresponding change in the effective grid to space charge capacity of the tube. Since this capacity is in series with the in-put transformer secondary 5, changes in that capacity produce a change in the phase relationship between the grid to cathode voltage and the in-put potential applied between the terminals A and B. The effect of this change in in-put capacity in the circuit illustrated in Fig. 1 is compensated for by employing the cathode compensating resistance 8.

It will be noted that the alternating grid current which flows through the grid to space charge capacity of the tube flows also through the resistance 8 and produces an alternating voltage across the resistance 8. This voltage is opposed to the alternating voltage between the grid and cathode, and since the magnitude of the alternating current flowing through the resistance 8 changes in accordance with changes in the magnitude of the grid to space charge capacity of the tube, the resistance 8 may be so chosen as to prevent changes in the grid bias of the tube from causing a change in cathode current in the in-put circuit. By preventing changes in the grid circuit current, the effect of the changing in-put capacity of the tube is neutralized and the phase relationship between the grid to cathode voltage and the in-put voltage across the terminals A and B is maintained constant.

The vacuum tube 1 also inherently includes an internal capacity between the plate and the cathode resulting from the proximity of these elements to each other. This capacity permits a reactive component of plate current to flow in the cathode circuit and so produces across the compensating resistor 8 a reactive voltage component which (unless its effects were neutralized) would be impressed on the in-put circuit of the tube, amplified by the tube and introduced into the out-put circuit as a reactive voltage. Since this reactive voltage is substantially in phase quadrature to the out-put voltage and since its magnitude depends on the amplification of the tube, it would cause a phase shift in the out-put voltage of the tube as the amplification of the tube were changed as by varying the grid bias.

In order to compensate for the effect of this reactive component of the plate current, I connect a neutralizing condenser 23 between the cathode of the tube and the lower end 24 of the plate transformer primary winding 12. It will be observed that the tap 21 on the winding 12 is maintained at ground potential with respect to alternating current and that the alternating potential of the lower end 24 is opposite in phase to the alternating potential of the plate of the tube. The neutralizing condenser 23 is thus connected in series with the plate to cathode capacity of the tube directly across the entire primary winding 12 and the mid tap between the plate to cathode capacity and the neutralizing condenser 23 is connected to the cathode of the tube.

By adjusting the neutralizing condenser 23 with respect to the voltage of the point 24, the voltage at the mid-point between the plate to cathode capacity and the neutralizing condenser 23 may be made equal to the alternating voltage developed across the compensating resistor 8, with the result that no reactive component of plate current is permitted to flow through this resistor. Thus, the phase relation between the alternating plate voltage and the in-put voltage applied to the terminals A and B is maintained constant irrespective of changes in the amplification of the tube.

The vacuum tube 1 also inherently includes a grid to plate capacity which must also be neutralized if the phase relationship between the in-put and out-put voltages of the amplifier are to be maintained constant. This is for the reason that the grid to plate capacity provides a reactive circuit through which a current may flow from the plate through the secondary 5 to ground. Since the voltage thus developed across the secondary 5 is not in phase with the voltage induced by the in-put voltage, the phase of the grid to cathode voltage would change as the magnitude of the alternating plate voltage were changed by variations in the amplification of the tube. For the purpose of neutralizing the grid to plate capacity I employ a neutralizing condenser 25 which is connected between the lower end 24 of the primary winding 12 and the grid circuit of the tube. While the connection from the condenser 25 to the grid circuit could well be made to the conductor 7, I prefer to employ a capacity divider comprising condensers 26 and 27 and a potentiometer 28 which are connected in series with each other in a circuit extending between the conductors 6 and 7. The neutralizing condenser 25 is preferably connected to the movable arm of the potentiometer 28.

Since, under the balanced condition, no voltage is to be developed across the secondary winding 5, the impedance of that winding under that balanced condition can be considered as infinite as far as the currents flowing under such conditions are concerned. Thus, the current flowing from the plate circuit through the plate to grid capacity to ground will flow through the capacity divider. The neutralizing current flowing through the neutralizing condenser 25 will also

flow through a part of the potentiometer 28 and the condenser 27. The voltage developed from the arm of the potentiometer 28 to ground by the sum of these two currents is adjusted so as to be equal and opposite to the voltage developed from the grid to the arm of the potentiometer 28 by the current passing through the grid to plate capacity. When this condition obtains, the sum of the voltages across the capacity divider produced by the current flowing through the neutralizing condenser 25 and through the plate to grid capacity of the tube is zero so that no reactive current component is caused to flow through the secondary winding 5.

It will be noted that this balanced condition is obtained solely by adjusting the constants of the capacity bridge circuit and thus that the neutralizing balance is obtained irrespective of changes in the secondary circuit 5 or the equivalent coupling or tuning circuit.

In the foregoing the voltage of the point 24 has been assumed to be opposite in phase to the alternating plate voltage of the tube 1. Due to mechanical reasons this may not necessarily be entirely true but such deviations from the desired out of phase condition may be adjusted by adjusting the position of the arm along the potentiometer 28.

By using the capacity divider on the input circuit and by including a fewer number of turns in the winding 12 between the tap 21 and the lower end 24 than is included in the remainder of the winding 12, I am permitted to employ as a neutralizing condenser 25 a condenser having a capacity considerably exceeding the plate to grid capacity of the tube. This is a consideration worthy of note since in multi-electrode vacuum tubes the grid to plate capacity may be extremely small so that if the neutralizing condenser 25 were connected directly to the grid of the tube, it would be substantially impossible to obtain commercially a condenser having a sufficiently small capacity to neutralize the grid to plate capacity of the tube. However, in the form shown, a relatively large capacity may be used for the neutralizing condenser 25, proper proportioning of the circuit constants permitting the use of a condenser having a capacity as much as one hundred times the grid to plate capacity of the tube.

I have illustrated in Fig. 2 a modified form of my invention. The in-put circuit of the amplifier is substantially the same as that illustrated in Fig. 1 except that a second compensating resistor 29 is inserted between the secondary winding 5 of the in-put transformer and ground. The resistor 29 is thus connected in the in-put circuit in series with the compensating resistor 8 which is provided in the cathode circuit and these two resistors coact to compensate for the effects of the changing in-put capacity of the tube in the same manner as that previously explained in connection with the single compensating resistance 8 employed in the circuit illustrated in Fig. 1.

The neutralizing of the plate to cathode capacity of the tube is accomplished by connecting a neutralizing condenser 30 between the ungrounded terminal 31 of the resistance 29 and a tap 32 provided on the primary 12 of the output transformer, the tap 32 being positioned on the plate side of the alternating current ground point 21.

In the form of invention illustrated in Fig. 1 the plate to cathode neutralizing condenser 23 was employed to neutralize the plate to cathode capacity of the tube and to prevent a reactive plate current component from flowing in the compensating resistor 8. In the form shown in Fig. 2, the reactive component of the plate current is allowed to flow through the resistor 8 but an equal reactive current component is caused to flow through the resistance 29 and the values of the resistance 29 and the capacity 30 are so chosen with respect to the voltage of the point 32 above ground as to cause the reactive voltage which is developed across the resistor 29 to be equal to the reactive voltage developed across the resistor 8 but opposite in phase relative thereto. Thus, the alternating voltages across the resistance 8 and 21 are opposed to each other and the effects of these voltages are cancelled with the result that no shift in phase of the alternating plate voltage of the tube will result from a change in grid bias of the tube.

Fig. 2 illustrates a conventional form of neutralizing circuit for neutralizing the plate to grid capacity of the tube which includes a neutralizing condenser 33 connected between the grid of the tube and the lower point 24 of the primary 12 of the plate transformer.

Fig. 3 illustrates a still further modified form of the invention in which the secondary 5 of the in-put transformer is tapped as at 34, the tapped point being connected to ground through the second compensating resistor 29 to thereby connect the resistors 8 and 29 in series in the in-put circuit in the same manner as that illustrated in Fig. 2. The plate to cathode and the plate to grid neutralizing circuits are combined, the plate being connected through a neutralizing condenser 35 to the tap 34 and being also connected through a second neutralizing condenser 36 to the lower end 37 of the secondary winding 5. Thus, the two condensers 35 and 36 together function in the same manner as does the neutralizing condenser 30 illustrated in Fig. 2, whereas, the condenser 36 alone serves the same purpose as does the neutralizing condenser 33 in Fig. 2.

It will be noted that in Fig. 2 the grid of the tube is connected through the neutralizing condenser 33 to a point on the primary winding 12 having a potential which is opposite in phase to the alternating plate potential of the tube. The connections are reversed in Fig. 3 in that the neutralizing condenser 36 is connected between a point in the plate circuit at which the potential is the same as that on the plate of the tube and a point in the grid circuit at which the potential is opposite in phase to the grid potential of the tube.

In the form of the invention illustrated in Fig. 4 the conventional type of plate to grid neutralization is employed, the plate neutralizing condenser 33 being connected between the grid of the tube and the point 24 on the primary 12 of the plate circuit transformer at which the alternating potential is opposite in phase to the alternating plate potential in a manner identical to that illustrated in Fig. 2.

The in-put neutralization is, however, accomplished by inserting a compensating resistance 38 in the plate circuit between the plate battery 17 and its connection to the primary winding 12 at the tap 21. The lower terminal of the in-put transformer secondary 5 is connected also to the tap 21 through a blocking condenser 39 and is connected to ground through a grid resistor 40. The grid resistor 40 is employed to maintain the

proper direct current potential on the grid of the tube and has a sufficiently high value of resistance to be neglected in the consideration of the alternating current circuits.

Thus, the external grid circuit of the tube includes the secondary winding **5**, the blocking condenser **39** and the compensating resistance **38**, the lower end of which is connected to ground through a by-pass condenser **41**. Thus, the external grid circuit illustrated in Fig. 4 is identical to that illustrated in Fig. 1 except that the ground connection has been shifted from the lower end of the secondary winding **5** to the cathode. Thus the effect of the compensating resistance **38** on the plate circuit of the amplifier may be neutralized by connecting a neutralizing condenser **42** between the point **24** and ground, this being the equivalent of the circuit illustrated in Fig. 1.

Attention is directed to the fact that the plate to cathode neutralization may be effected by balancing the reactive voltages in the manner illustrated in Figs. 1 and 4 to prevent the flow of reactive current in the grid to space charge compensating resistor or instead reactive currents may be caused to flow in opposite directions through sections of the grid to space charge compensating resistor to produce equal and opposite bucking voltages in the manner illustrated in Figs. 2 and 3.

From the foregoing it will be observed that I have provided a novel thermionic alternating voltage amplifier circuit which operates to maintain a fixed phase relationship between the input and out-put voltages irrespective of changes in the internal capacities of the tube resulting from changing the grid bias and the amplification of the tube.

While I have in the foregoing referred to changing the grid to cathode or grid to space charge capacity of the tube by changing the grid bias, it will be realized that changing the operating voltage applied to other elements of the tubes will similarly cause changes in the grid to cathode capacity. Such other changes may include changes in the plate voltage or changes in the screen or suppressor voltages in the case of the multi-element tubes.

Furthermore, reference is made hereinbefore solely to the feature of maintaining a fixed phase relation between the in-put and out-put voltages of the amplifier. It will be realized, however, that the amplifier circuit of my invention also finds great utility under those circumstances where a change in the grid to cathode capacity would change the tuning or the resonant frequency of the circuit. One such condition is found in ultra-high frequency radio work where the resonant circuits include small capacities and a high ratio of inductance to capacity.

It will be further noted that I have illustrated and described a number of equivalent circuits each operating in substantially the same manner to produce the results described above.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown or described herein, except as defined in the appended claims.

I claim:

1. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a plate and a cathode; means for applying a variable grid bias voltage to said grid; an in-put circuit including a coupling means connected to said grid and said cathode; an out-put circuit including a coupling means connected to said plate and said cathode; compensating means to neutralize the effect of changes in said in-put circuit capacity coupling between said grid and the space charge of said thermionic vacuum tube and resulting from variations in said grid bias voltage, said compensating means comprising a resistance in series with said cathode, at least a part of said resistance being common to both in-put and out-put circuits; means including a condenser connected from a point in said in-put circuit to a point in said out-put circuit for preventing changes in the effective capacity of said in-put circuit caused by variations in the ratio of in-put to out-put voltages; and means including a condenser connected from said out-put circuit to said resistance for preventing changes in the effective capacity of said out-put circuit caused by the combined effects of said resistance and plate to cathode capacity.

2. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a plate and a cathode; means for applying a variable grid bias voltage to said grid; an in-put circuit including a coupling means connected to said grid and said cathode; an out-put circuit including a coupling means connected to said plate and said cathode; compensating means to neutralize the effect of changes in said in-put circuit capacity coupling between said grid and the space charge of said thermionic vacuum tube and resulting from variations in said grid bias voltage, said compensating means comprising a resistance in series with said cathode, at least a part of said resistance being common to both in-put and out-put circuits; and means including a condenser connected from a point in said in-put circuit to a point in said out-put circuit for preventing changes in the effective capacity of said in-put circuit caused by variations in the ratio of in-put to out-put voltages.

3. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a plate and a cathode; means for applying a variable grid bias voltage to said grid; an in-put circuit including a coupling means connected to said grid and said cathode; an out-put circuit including a coupling means connected to said plate and said cathode; compensating means to neutralize the effect of changes in said in-put circuit capacity coupling between said grid and the space charge of said thermionic vacuum tube and resulting from variations in said grid bias voltage, said compensating means comprising a resistance in series with said cathode, at least a part of said resistance being common to both in-put and out-put circuits; and means including a condenser connected from said out-put circuit to said resistance for preventing changes in the effective capacity of said out-put circuit caused by the combined effects of said resistance and plate to cathode capacity.

4. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube also having a grid to cathode capacity and a plate to cathode capacity; an in-put circuit including an in-put coupling means connected to said grid and said cathode; means in said in-put circuit to compensate for changes in said grid to cathode capacity resulting from changes in the operating voltages of said tube and maintain a fixed current in said in-put circuit resulting from an alternating voltage impressed across said cou-

pling means; an out-put circuit including an out-put coupling means connected to said plate and said cathode; and neutralizing means connected between said in-put and out-put circuits for neutralizing the effect of said plate to cathode capacity to thereby maintain a fixed phase relationship between said voltage applied across said in-put coupling means and the voltage across said out-put coupling means.

5. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube having also a grid to cathode capacity and a plate to cathode capacity; an in-put circuit including an in-put coupling means connected to said grid and said cathode; an out-put circuit including an out-put coupling means connected to said plate and said cathode; a compensating resistance connected in series with said cathode and common to both said in-put and out-put circuits to compensate for changes in said grid to cathode capacity resulting from changes in the operating voltages of said tube to thereby maintain a fixed current in said in-put circuit resulting from an alternating voltage applied across said in-put coupling means; and neutralizing means connected between said in-put circuit and said out-put circuit for neutralizing said plate to cathode capacity to maintain a fixed phase relationship between said voltage applied to said in-put coupling means and the alternating voltage across said out-put coupling means.

6. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube having also a grid to cathode capacity, a plate to cathode capacity and a plate to grid capacity; an in-put circuit including an in-put coupling means connected to said grid and said cathode; compensating means in said in-put circuit for maintaining a fixed current in said in-put circuit resulting from an alternating voltage applied across said in-put coupling means; neutralizing means connected between said out-put circuit and said in-put circuit to neutralize the effect of said plate to grid capacity; and a second neutralizing means connected between said in-put and said out-put circuits for neutralizing the combined effect of said compensating means and said plate to cathode capacity to thereby maintain a fixed phase relation between said voltage applied to said in-put coupling means and the alternating voltage across said out-put coupling means irrespective of changes in said grid to cathode capacity resulting from changes in the operating voltages of said tube.

7. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate. said tube having also a grid to cathode capacity and a plate to cathode capacity; an in-put circuit including said grid and said cathode; an out-put circuit including said plate and said cathode; a resistance in series with said cathode and common to said in-put and out-put circuits; and a capacity connected from said cathode to a point in said out-put circuit at which the alternating potential is substantially opposite in phase to the alternating potential of said plate.

8. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube having also a grid to cathode capacity, a plate to cathode capacity and a plate to grid capacity; an in-put circuit including said grid and said cathode; an

out-put circuit including said plate and said cathode; a resistance connected in series with said cathode and common to both said in-put and out-put circuits to compensate for changes in said grid to cathode capacity resulting from changes in the operating voltages of said tube; a capacity connected between selected points on said in-put and out-put circuits, said points being so selected that the alternating voltage between said points is substantially opposite in phase to the alternating voltage between said grid and said plate, whereby said plate to grid capacity is neutralized; and a second capacity included in a circuit extending from said cathode to a point on said out-put circuit at which the alternating voltage is substantially opposite in phase to the alternating voltage of said plate, whereby said plate to cathode capacity is neutralized.

9. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube having also a grid to cathode capacity and a plate to cathode capacity; an in-put circuit including said grid and said cathode; an out-put circuit including said plate and said cathode; a resistance connected in series with said cathode and common to both said in-put and out-put circuits; and a neutralizing capacity connected in a circuit extending from said cathode to a point on said out-put circuit at which the alternating voltage is substantially opposite in phase to the alternating voltage of said plate, said point on said out-put circuit and the magnitude of said neutralizing capacity being so selected that the alternating current flowing from said point to said cathode through said neutralizing capacity is equal in magnitude and opposite in phase to the alternating current flowing from said plate to said cathode through said plate to cathode capacity.

10. In an alternating voltage amplier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube having also a grid to cathode capacity and a plate to cathode capacity; an in-put circuit including said grid and said cathode; an out-put circuit including said plate and said cathode; a pair of compensating resistances connected in series in said in-put circuit, one of said resistances being common to both said in-put and said out-put circuits; and a neutralizing capacity included in a circuit extended from a selected point in said out-put circuit at which the alternating voltage is substantially in phase with the alternating voltage of said plate to a point on said in-put circuit disposing both of said resistances between said point and said cathode, the magnitude of said neutralizing capacity and the point on said out-put circuit being so selected that the alternating voltage developed in the other of said resistances by current flowing through said neutralizing capacity and said other resistance is substantially equal and opposite in phase to the alternating voltage developed across said one resistance by alternating current flowing through said plate to cathode capacity and said one resistance.

11. In an alternating voltage amplier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate; an in-put circuit including an in-put coupling means connected to said grid and said cathode; an out-put circuit including an out-put coupling means connected to said plate and said cathode; a resistor in series with said cathode and common to both said in-put and out-put circuits; and a condenser connected from said cathode to a point on said out-

put circuit at which the alternating voltage is substantially opposite in phase to the alternating voltage of said plate.

12. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube also having a grid to cathode capacity and a plate to cathode capacity; an in-put circuit including an in-put coupling means connected to said grid and said cathode; an out-put circuit including an out-put coupling means connected between said plate and said cathode; compensating means in said in-put circuit to compensate for changes in said grid to cathode capacity resulting from changes in the operating voltages of said tube, said compensating means being so located as to permit coupling between said input circuit and said out-put circuit through said plate to cathode capacity; and a neutralizing means connected between said in-put and out-

put circuits for neutralizing said coupling between said in-put and out-put circuits.

13. In an alternating voltage amplifier, the combination of: a thermionic vacuum tube including a grid, a cathode and a plate, said tube having also a grid to cathode capacity and a plate to cathode capacity; an input circuit including said grid and said cathode; an output circuit including said plate and said cathode; a resistance in series with said cathode and common to said input and output circuits; and a capacity connected from said cathode to a point in said output circuit at which the alternating potential is substantially opposite in phase to the alternating potential of said plate, said capacity having such magnitude as to neutralize the intercoupling of said output and input circuits caused by said plate to cathode capacity and said resistance.

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