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NONSINGING AMPLIFIER

Filed Nov. 10, 1928

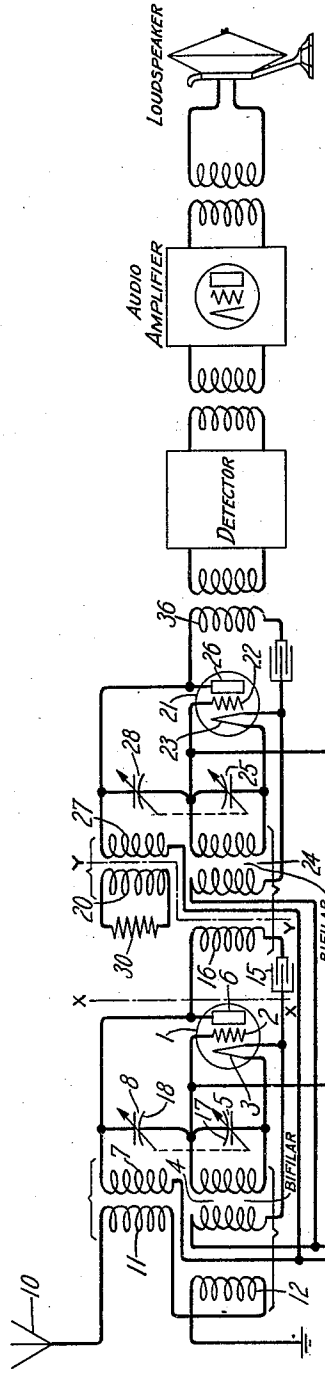

FIG. 1

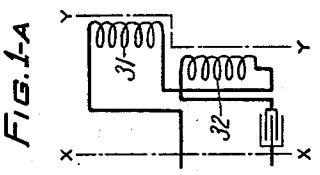

FIG. 1-A

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NON-SINGING AMPLIFIER

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This invention relates to high frequency vacuum tube amplifiers and more particularly to improved circuits whereby the operating efficiency of such amplifiers is increased.

A general object of the invention is to prevent undesirable singing or regeneration in high frequency amplifier circuits.

The prevention of singing due to the inter-electrode capacity requires that the retro-active E. M. F. (or feed back) at all times be zero or else in such phase relation with respect to the input E. M. F. as to produce loss of amplification (or degeneration). In accordance with the present invention this is accomplished by maintaining constant similarity of the impedances between the plate and grid and between the filament and grid. This produces a degenerative action at all frequencies and also makes the degenerative action substantially constant at all frequencies.

Two simple tuned circuits are employed which by virtue of mechanical coupling of the tuning elements are always resonant at the same frequency, one circuit being connected between the grid and filament and the other between the grid and plate. By this means, the impedances of the two paths are maintained similar at all frequencies and a constant degenerative feed back is secured. By incorporating the plate to grid branch as part of the input circuit along with the grid-filament branch, two input E. M. F.'s are introduced, which by the proper poling of the circuits, may be made additive with respect to the normal amplifying action of the tube, and may be made to substantially neutralize each other with respect to the direct transmission of currents to the output circuit through the impedances of the tube. The input circuit may for example be coupled inductively to both the circuit between grid and filament and the circuit between grid and plate. Preferably then the couplings will be reversed with respect to each other in phase and balanced in degree so that no current is directly transmitted to the space path or the output circuit. In this case the two input voltages aid in producing amplification.

Both resonant circuits may be tuned by means of a variable condenser, in which case it is desirable that their rotors be at AC ground potential to avoid the disturbances due to hand capacities, and to simplify their mechanical connector. This may be done by supplying the filament current through parallel inductive windings and arranging these windings so that they will comprise a part of the tuning circuit between grid and filament; supplying the plate potential through the inductive winding connected between the grid and plate; and grounding the grid of the vacuum tube. A blocking condenser is employed between the plate and output winding to prevent the plate potential from being impressed on the filament of the vacuum tube.

The invention will be better understood by referring to the following description and accompanying drawings showing preferred forms of embodiment.

Fig. 1 represents a radio receiving circuit comprising two stages of radio frequency amplification, a detector, an audio amplifier and a loud speaker.

Fig. 1—A is a modified form of that portion of Fig. 1 between lines X—X and Y—Y.

Referring to Fig. 1 the amplifier tube 1 has an input circuit between grid 2 and filament 3 which consists of a coil 4 across which is connected a tuning capacity 5, and an input circuit between grid 2 and plate 6 which consists of a coil 7 across which is connected a tuning capacity 8. Coil 4 has a bifilar winding, one end of the bifilar windings being connected to the terminals of the filament 3 of vacuum tube 1 and the other end connected across the filament battery 9. The antenna 10 is inductively coupled to coils 4 and 7 by means of coils 11 and 12.

Potential is supplied to the plate 6 from a battery 13 through coil 7. Suitable capacities may be connected across the filament battery 9 and plate battery 13 to provide low impedance paths for high frequency currents. Connected between the plate 6 and the filament 3 are a condenser 15 and an output winding 16. The condenser 15 may be of any suitable character as it serves merely as a blocking condenser to prevent positive

"B" potential 13 from reaching the filament 3.

Tuning condensers 5 and 8 are preferably connected to the same control so that both resonant circuits 4—5 and 7—8 may be tuned together. Preferably also, the rotors 17 and 18 of condensers 5 and 8 are connected to grid 2. This arrangement permits grounding the grid 2 of thermionic tube 1 as shown at 19. The effect of hand capacities on condensers 3 and 5 is thereby reduced to a minimum.

Since both resonant circuits are tuned at the same time, no singing takes place even when the circuits are being tuned to the desired frequency because of the fact that the similarity of the impedances of the two circuits 4—5 and 7—8 maintains the grid 2 constantly at an oscillating potential midway between the plate 6 and the filament 3. Furthermore, by maintaining constant the similarity of the impedances between plate 6 and grid 2 and between the grid 2 and the filament 3 a degenerating action takes place which is substantially constant at all frequencies. The amount of degeneration can be controlled by varying the values of the impedances of circuits 4—5 and 7—8. As the impedance of circuit 7—8 is increased over that of circuit 4—5, the amount of degeneration decreases. The impedances will be in the ratio of the inductances of the tuning coils when appropriate tuning condensers are used.

The coupling from the antenna circuit to the input circuit of vacuum tube 1 through coils 11 and 12 is reversed with respect to the input circuits and balanced so that no current flows from plate 6 and grid 2. The input voltages to coils 4 and 7 then aid in producing amplification.

The second stage of high frequency amplification comprises an amplifier tube 21 having an input circuit similar to that of amplifier tube 1 and comprising an input coil 24 connected between grid 22 and filament 23, and an input coil 27 connected between grid 22 and plate 26. Coils 24 and 27 are inductively coupled. Variable condensers 25 and 28 are connected across coils 24 and 27, respectively, for tuning purposes. As indicated by the dotted lines, they are preferably tuned at the same time in a manner similar to condensers 5 and 8.

An additional circuit 20—30 comprising an inductance coil 20 and an impedance 30 is inductively coupled to coil 27. Coils 16 and 20 are so constructed as to have similar characteristics. The value of the impedance 30 is preferably made the same as the plate filament impedance of vacuum tube 1. This circuit 20—30 then simulates the effect of the circuit 15—16 which is inductively coupled to circuit 24—25. Circuit 20—30 will in general be unnecessary when coils 16 and 24 are loosely coupled. In this case only one input, E. M. F. is present, and a certain direct transmission may take place between the input and the output circuits of the tube. The non-oscillating qualities of the circuit are however not affected.

The output circuit of vacuum tube 21 is coupled through coil 36 to a detector circuit so that the signaling waves pass to the detector and from the detector through the audio amplifier to the loud speaker. If still greater amplification of the high frequency signals is desired an additional stage or stages similar to the two shown, can be added.

The modified interstage radio frequency coupling arrangement of Fig. 1—A comprises two inductances 31 and 32 connected in the output circuit of thermionic tube 1 having their couplings reversed with respect to each other. Inductance 31 is inductively coupled to inductance 27 and inductance 32 is inductively coupled to inductance 24. The input voltages to coils 24 and 27 then aid in producing amplification.

The circuit of Fig. 1 has been illustrated and described as employing different circuit connections in the two radio frequency stages. It will be understood, of course, that this is for purposes of illustration and that it is within the invention to employ either identical or different types of circuits in the different stages. For example, to use the same type of connection for stage 2 that is used for stage 1 it is merely necessary to replace the elements included between the lines X—X and Y—Y of Fig. 1 by the elements shown in Fig. 1—A.

While several embodiments of the invention have been shown and described in detail, it is understood that the invention is generic in character and is not to be construed as limited to these particular embodiments since numerous modifications thereof may be made by persons skilled in the art without departing from the spirit of applicant's invention, the scope of which is to be determined by the appended claims.

What is claimed is:

1. The combination of an evacuated vessel having a plurality of electrodes including a grid, a plate and a filament, a source of oscillations of an ultra-audio frequency, and means coupled to said source of oscillations for maintaining the grid constantly at an oscillating potential intermediate between the plate and the filament, said means comprising two circuits resonant at the same frequency, one connected between grid and plate and the other between grid and filament.

2. In an electrical system comprising a thermionic device having a control electrode, an anode, and a cathode, means for grounding said control electrode, an input circuit, an output circuit including the anode and cath-

ode, a part of said input circuit including said control electrode and said cathode, another part of said input circuit including said control electrode and said anode.

3. Radio frequency amplifying apparatus comprising a thermionic vacuum tube having a filament, grid and plate, two equal inductances, a pair of simultaneous adjustable condensers of equal capacity connected in effective shunt to said inductances, and adapted to tune said inductances, to resonance with a signal, means associated with said condensers whereby the adjustment of one is accompanied by the adjustment of the other, leads from said filament to one end of one of said inductances, a lead from said plate to one end of the other of said inductances, a connection from said grid to the other ends of said inductances, said connection to one of said inductances including a capacity, and an inductance and a capacity in the output circuit of said tube.

4. Radio frequency amplifying apparatus comprising a thermionic vacuum tube having a filament, grid and plate, two equal inductances, one of said inductances comprising two conductors bifilar wound to permit the filament to have one D. C. potential and a different A. C. potential with respect to the other electrodes, a pair of simultaneous adjustable condensers of equal capacity connected in effective shunt to said inductances and adapted to tune said inductances to resonance with a signal, means associated with said condensers whereby the adjustment of one is accompanied by the adjustment of the other, leads from said filament to said bifilar wound inductance, a lead from said plate to one end of the other of said inductances, a connection from said grid to the other end of said inductance connected to said plate and a connection from said grid to one of the two conductors of said bifilar wound inductance, said connection to said inductance connected to said plate including a capacity, and an inductance and a capacity in the output circuit of said tube.

5. Radio frequency amplifying apparatus comprising a thermionic vacuum tube having a filament, grid and plate, an inductance, a variable capacity connected in effective shunt to said inductance and adapted to tune said inductance to resonance with a signal, a lead from said plate to one end of said inductance, a connection from said grid to the other end of said inductance, said connection including a capacity, a second inductance comprising two conductors bifilar wound, a variable capacity connected in effective shunt to one of said bifilar windings, and adapted to tune said inductance to resonance with said signal, a connection from one end of said last mentioned bifilar winding to said grid, connections from the other ends of said bifilar windings to said filament, and an inductance and a capacity in the output circuit of said tube.

6. A radio receiving circuit comprising an antenna circuit, a plurality of three-element radio frequency amplifier tubes having a grid, a plate and a filament and connected in cascade, each of said radio frequency amplifier tubes having associated therewith an inductance, a variable capacity connected in effective shunt to said inductance, and adapted to tune said inductance to resonance with a signal, a lead from said plate to one end of said inductance, a connection from said grid to the other end of said inductance, said connection including a capacity, a second inductance comprising two conductors bifilar wound, a variable capacity connected in effective shunt to one of said bifilar windings, and adapted to tune said inductance to resonance with said signal, a connection from one end of said last mentioned bifilar winding to said grid, connections from the other ends of said bifilar windings to said filament, and an inductance and a capacity in the output circuit of said tube, a detector circuit coupled to the output circuit of the last radio frequency amplifier tube, an audio amplifying circuit, and a sound reproducing device, said antenna circuit including two inductances having their couplings reversed with respect to each other, one of said antenna inductances inductively coupled to said inductance connected between grid and plate, and the other of said antenna inductances coupled to said inductance connected between grid and filament.

7. Radio frequency amplifying apparatus comprising a thermionic vacuum tube having a filament, grid and plate, an inductance, a variable capacity connected in effective shunt to said inductance and adapted to tune said inductance to resonance with a signal, a lead from said plate to one end of said inductance, a connection from said grid to the other end of said inductance, said connection including a capacity, a second inductance inductively coupled to said first mentioned inductance, said last mentioned inductance comprising two conductors bifilar wound, a variable capacity connected in effective shunt to one of said bifilar windings, and adapted to tune said inductance to resonance with said signal, a connection from one end of said last mentioned bifilar winding to said grid, connections from the other ends of said bifilar windings to said filament, an inductance and a capacity in the output circuit of said tube, an input circuit inductively coupled to said bifilar wound inductance and a circuit comprising an inductance and an effective resistance, simulating the inductance and effective resistance of said input circuit, inductively coupled to said inductance connected between said grid and plate.

8. A radio receiving circuit comprising an antenna circuit, a plurality of three-element

radio frequency amplifier tubes having a grid, a plate and a filament and connected in cascade, each of said radio frequency amplifier tubes having associated therewith an inductance, a variable capacity connected in effective shunt to said inductance, and adapted to tune said inductance to resonance with a signal, a lead from said plate to one end of said inductance, a connection from said grid to the other end of said inductance, said connection including a capacity, a second inductance comprising two conductors bifilar wound, a variable capacity connected in effective shunt to one of said bifilar windings, and adapted to tune said inductance to resonance with said signal, a connection from one end of said last mentioned bifilar winding to said grid, connections from the other ends of said bifilar windings to said filament, and an inductance and a capacity in the output circuit, each of said radio frequency amplifier tubes, with the exception of the tube connected to said antenna circuit, having a circuit comprising an inductance and an effective resistance which simulates the inductance and effective resistance of the output circuit of the preceding amplifier tube inductively coupled to said inductance connected between said grid and plate, a detector circuit, an audio amplifying circuit and a sound reproducing device, said antenna circuit including two inductances having their couplings reversed with respect to each other, one of said inductances inductively coupled to said inductance connected between grid and plate, and the other of said antenna inductances coupled to said inductance connected between grid and filament.

9. In a radio system of communication the combination with a three-electrode thermionic tube having an input circuit and an output circuit of an input transformer having two secondaries in said input circuit, one of said secondaries connected between the control electrode and anode of said thermionic tube and the other of said secondaries connected between said control electrode and the cathode of said thermionic tube, said secondary windings of said input transformer operating to maintain said control electrode constantly at an oscillating potential intermediate between said anode and cathode, an output transformer having a primary in said output circuit, and adjustable capacitances connected across said input secondary windings.

10. A radio receiving circuit in accordance with claim 6, characterized in this that the inductance in the output circuit of each of said radio frequency amplifier tubes, with the exception of the output circuit connected to the detector input, consists of two parts having their couplings reversed with respect to each other, one inductively coupled to the inductance connected between the grid and the plate of the following radio frequency amplifier tube and the other inductively coupled to said inductance connected between the grid and filament of said last mentioned tube.

11. The combination with an evacuated vessel having a plurality of electrodes, of a source of oscillations of an ultra-audio frequency and means comprising a circuit resonant to said frequency connected between two of said electrodes and coupled to said source of oscillations for neutralizing the capacity effects between said two electrodes for said frequency.

12. In an amplifier circuit comprising an audion having a grid, an anode and a cathode and having capacity between the grid and the anode and having a tuned input circuit between said grid and said cathode, means for preventing regeneration due to said grid-anode capacity comprising a tuned circuit connected between grid and anode and tuned syntonously with said tuned input circuit.

13. The combination with a vacuum tube having a plurality of electrodes between two of which electrodes there is a capacity tending to produce regeneration, of a source of oscillations of a certain frequency, and means comprising a circuit resonant to said certain frequency connected between said two electrodes and coupled to said source of oscillations for neutralizing the regenerative capacity effect between said two electrodes for said certain frequency.

14. The combination defined in claim 9, including also a wave source, and means for coupling said wave source to each of said tuned circuits.

15. The combination defined in claim 9, including also an incoming circuit coupled to the inductances of each of said tuned circuits and poled with respect thereto to produce excitation therein in opposing phases.

In witness whereof, I hereunto subscribe my name this 8th day of November, 1928.

GEORGE H. STEVENSON.