March 10, 1936. C. E. FAY 2,033,278

VACUUM TUBE AMPLIFIER

Filed June 8, 1933

FIG. 1

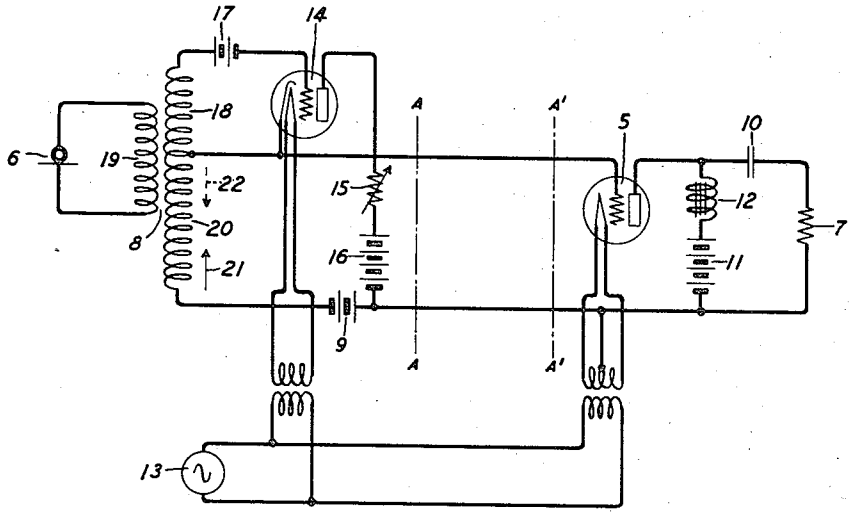
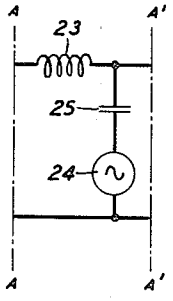


FIG. 1-A



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VACUUM TUBE AMPLIFIER

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6 Claims. (Cl. 179—171)

This invention relates to amplifying systems employing vacuum tubes and more particularly to input circuits for power amplifiers.

An object of the invention is to reduce the wave distortion which arises from the flow of grid current in a vacuum tube amplifier.

Another object is to compensate the adverse effects of grid current flow, particularly in a circuit supplying the amplifier with a wave to be amplified.

A further object is to increase the power output of undistorted waves obtainable from a vacuum tube amplifier.

As a result of the usual practice of maintaining the grid electrode of an amplifier tube continuously negative during operation, the tube is not used to the full power capacity that it has when the grid is permitted to become alternately positive and negative with respect to the cathode. The difficulty with a positive grid swing lies in the pronounced difference between the grid-cathode impedance at positive and negative potentials, which causes wave distortion when a wave source of fixed impedance is connected to the tube through circuits arranged for efficient transfer of voltage variations to the grid.

It has been proposed to limit the impedance variation by connecting a low impedance shunt between the grid and cathode and by using a low impedance wave source. While the distortion is largely avoided by these expedients, the gain of the amplifying system is reduced thereby and it may be necessary to use additional amplifying stages to compensate the loss.

In accordance with the present invention the grid current of an amplifier tube is supplied by an auxiliary current source connected in the input circuit of the amplifier and arranged to operate synchronously with the amplifier grid voltage in such a manner that when the grid voltage swings to a positive value current is drawn from the auxiliary source in the required amount. By this means the grid current load is removed from the wave source and the distortion arising therefrom is eliminated.

The auxiliary current source comprises a three-electrode vacuum tube and a suitable source of space current. The space path circuit of the tube is connected in series with the current source across the input of the amplifier, the cathode of the auxiliary tube being connected to the amplifier grid. The flow of space current in this path is controlled by the grid of the auxiliary tube which is so polarized that the space current is normally zero and, in addition, is connected with an exciting circuit controlled by the wave source which unblocks the space path whenever the amplifier grid voltage becomes positive.

During the positive swing of the amplifier grid the auxiliary tube supplies grid current for the amplifier in the correct amount and with proper variations to compensate for the distorting effects of the grid-cathode impedance variations. Being under the control of the wave source the action of the auxiliary tube is synchronized with the impedance variation. The power consumed by the auxiliary tube is merely that required to supply the grid losses of the amplifier, which are small compared with the increment which the amplifier anode is thereby enabled to handle. The added tube is thus utilized to better advantage as a compensator than it could be in a preliminary amplifying stage, for no amount of pre-amplification can of itself increase the output of the final stage for undistorted power.

The invention is described in detail hereinafter in connection with the accompanying drawing, in which

Fig. 1 represents schematically the preferred form of the invention as embodied in an amplifier; and

Fig. 1—A is a fragmentary diagram showing a modification of a portion of the system of Fig. 1 to form a modulating amplifier.

Fig. 1 shows an amplifying tube 5 inserted between a signal source or microphone 6 and a load circuit 7. The source is connected through a three winding input transformer 8 to the grid and cathode of the tube, a biasing battery 9 being connected in series with the transformer secondary. The load circuit is connected to the anode through a stopping condenser 10 and the space current is supplied by a battery 11, through a choke coil 12. The filament of tube 5 is heated by current from an alternating current source 13.

An auxiliary tube 14 has its cathode connected to the grid lead of the amplifying tube 5 and its anode connected through an adjustable resistance 15 and space current source 16 to the cathode of tube 5. The grid of the auxiliary tube is connected through a biasing battery 17 to a secondary winding 18 in transformer 8. The other windings of this transformer are designated 19 and 20 and are primary and secondary windings, respectively. The cathode of tube 14 is indirectly heated by a filament supplied with current from source 13, and the cathode is insulated from the heating circuit.

In the operation of the system of Fig. 1 the amplifier 5 and associated circuits are adjusted

in the usual manner except that the biasing battery 9 is of very small voltage or is omitted entirely as it is desired that the potential of the grid of tube 5 shall swing positive as well as negative. The battery 17 and secondary winding 18 are proportioned so that the anode current of tube 14 is completely shut off except during such times as grid current flows in tube 5. Tube 14 operates as a variable shunt impedance across the grid-cathode circuit of tube 5, controlling the flow of current from source 16 in accordance with the demand for grid current in tube 5 and preventing a voltage drop in winding 20. Battery 17 is of sufficient voltage to prevent the grid of tube 14 becoming positive at any time, which condition would result in undesirable power loss in that tube and imperfect control of the current from source 16. It will be noted that the grid current of the main tube tends to flow upward through winding 20 as indicated by the arrow 21. This tendency is opposed by the anode current of tube 14 which, with suitable poling of winding 18, tends to flow downward through winding 20 as indicated by the arrow 22. By adjusting the various controls of tube 14 the flow of grid current through winding 20 is substantially annulled. The grid current is then confined to the path comprising grid and anode of tube 5, battery 16, resistance 15, and anode and cathode of tube 14. Fine adjustment of the balance may be effected by means of resistance 15. Tube 14 may be of very much smaller power carrying capacity than tube 5 as the former is only called upon to supply an anode current equal to the grid current of the amplifier.

Fig. 1—A shows how that portion of the system of Fig. 1 between the broken lines AA and A'A' may be modified so that the amplifier becomes a modulating amplifier. A high frequency choke coil 23 is inserted in series with the grid of tube 5 and a high frequency carrier generator 24 and stopping condenser 25 are connected in parallel between the grid and cathode. In addition, choke coil 12 should be modified as required to make it effective at the carrier frequency.

The operation of the system as modified is substantially the same, as in the case of the amplifier, the output now being a modulated high frequency wave. The compensating feature operates to reduce distortion of the envelope of the modulated wave.

What is claimed is:

1. A grid current compensator comprising an auxiliary tube connected between the grid and cathode of a main amplifier tube, the cathode of the auxiliary tube being connected to the main tube grid and the anode to the main tube cathode, a source of waves to be amplified, a supply circuit for impressing waves from said source upon said main tube and said auxiliary tube simultaneously, and means for adjusting the anode cathode impedance of the auxiliary tube to match the grid-cathode impedance of the main tube, whereby the voltage impressed upon said supply circuit by the grid current of the main tube is substantially annulled by a similar voltage impressed upon said circuit by the anode current of the auxiliary tube.

2. In combination, a signal source, an amplifier tube, and an auxiliary tube, means for coupling the signal source to the grid circuit of the amplifier tube and also to the grid circuit of the auxiliary tube, and means for coupling the signal source to the anode circuit of the auxiliary tube independently of the grid of said auxiliary tube, said last mentioned coupling being so poled with respect to the coupling between the signal source and the amplifier grid circuit that the amplifier grid current and the auxiliary tube anode current are opposed to each other in their effects upon the signal source.

3. In combination, a signal source, an amplifier tube, and an auxiliary tube, means for coupling the signal source to the grid circuit of the amplifier tube and also to the grid circuit of the auxiliary tube, and means for coupling the signal source to the anode circuit of the auxiliary tube independently of the grid of said auxiliary tube, said last mentioned coupling being so poled with respect to the coupling between the signal source and the amplifier grid circuit that the amplifier grid current and the auxiliary tube anode current induce opposing electromotive forces in circuit with the signal source.

4. In combination, a signal source, an amplifier tube, and an auxiliary tube, means for coupling the signal source to the grid circuit of the amplifier tube and also to the grid circuit of the auxiliary tube, means for coupling the signal source to the anode circuit of the auxiliary tube independently of the grid of said auxiliary tube, said last mentioned coupling being so poled with respect to the coupling between the signal source and the amplifier grid circuit that the amplifier grid current and the auxiliary tube anode current are opposed to each other in their effects upon the signal source, and means to adjust the relative magnitudes of said effects.

5. In combination, a signal source, an amplifier tube, and an auxiliary tube, means for coupling the signal source to the grid circuit of the amplifier tube and also to the grid circuit of the auxiliary tube, means for coupling the signal source to the anode circuit of the auxiliary tube independently of the grid of said auxiliary tube, said last mentioned coupling being so poled with respect to the coupling between the signal source and the amplifier grid circuit that the amplifier grid current and the auxiliary tube anode current are opposed to each other in their effects upon the signal source, and means to adjust the magnitude of the auxiliary tube anode current whereby said effects may be annulled.

6. In combination, a source of waves to be amplified, an amplifier tube, an auxiliary tube, two-way coupling means connecting the source with the amplifier grid circuit allowing actuation of the amplifier tube by waves from said source and permitting the amplifier grid current to react upon the source, means coupling the source with the auxiliary tube to effect variations in the anode current of said tube, and two-way coupling means connecting the auxiliary anode circuit with the source to permit the auxiliary anode current to react upon said source, the coupling from the auxiliary anode circuit to the source being such as to oppose the coupling from the amplifier grid circuit to the source, whereby the reactions of the amplifier grid current and the auxiliary anode current upon the source are opposed to each other and the resultant reaction is reduced.

CLIFFORD E. FAY.