

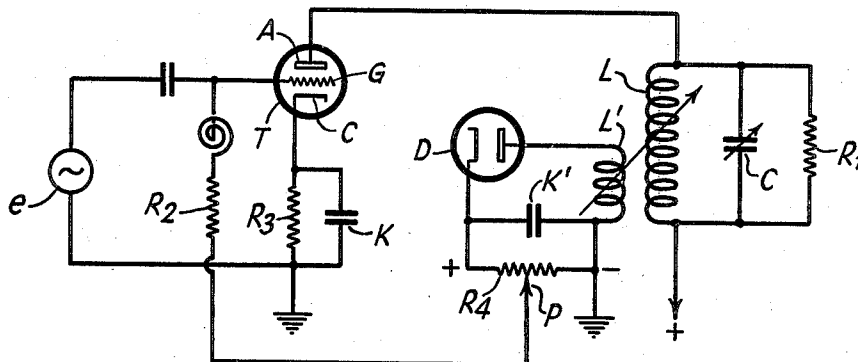
June 24, 1941.

W. VAN B. ROBERTS

2,247,203

AMPLIFIER CIRCUIT

Filed Jan. 7, 1939



INVENTOR.
WALTER VAN B. ROBERTS
BY *H. S. Snover*
ATTORNEY.

UNITED STATES PATENT OFFICE

2,247,203

AMPLIFIER CIRCUIT

Walter van B. Roberts, Princeton, N. J., assignor
to Radio Corporation of America, a corporation
of Delaware

Application January 7, 1939, Serial No. 249,752

6 Claims. (Cl. 179—171)

This invention relates to electron discharge device amplifier circuits, and more particularly to a method of and means for biasing power amplifiers, whereby the bias varies as a function of several operating conditions.

It is known that amplifier stages as heretofore employed are often overloaded due to such factors as grid excitation failure, improper tuning of the plate tank circuit, and excessive loading. To avoid excessive plate dissipation upon failure of grid excitation, it has been suggested to utilize a cathode bias resistor with the idea that excessive plate current is prevented by the resulting increasing bias. However, a sufficiently large bias resistor to accomplish this result will usually produce too much bias under normal operating conditions because a much larger plate current is permissible in the presence of a large power output than in the absence of excitation or output. It has therefore been further proposed to utilize for a cathode bias resistor a material having a resistance which decreases rapidly with increasing current density so as to maintain a bias voltage sufficiently independent of plate current for many practical purposes. However, there still remains the possibility of excessive heating in case the plate tank circuit is improperly tuned or overloaded in the presence of excitation.

A primary object of the present invention is to provide a biasing arrangement for an amplifier which will insure sufficient bias voltage to safeguard the amplifier tube, in case any of the following conditions occur: (1) Grid excitation failure, (2) improper plate circuit tuning, or (3) excessive plate circuit loading, while at the same time supplying only sufficient bias for efficient operation in the presence of proper excitation and plate circuit tuning and loading.

A particular object of the invention is to provide a bias voltage for the amplifier tube, which voltage varies as a function of amplifier output even though the plate current and excitation remain unchanged.

The invention may be best described by reference to the accompanying drawing which represents one form of the invention. In the drawing, T is an amplifier vacuum tube having a cathode C, a grid G and a plate A. Tube T receives grid excitation from alternating current source *e* and delivers power to a load represented by R_L connected across the tuned plate tank circuit L, C. To prevent excessive dissipation in the absence of grid excitation, a sufficiently large resistance R_3 is connected in the cathode circuit and shunted by radio frequency by-pass condenser K. To provide a grid bias which increases with increasing grid excitation, there is provided in the grid circuit a resistance R_2 whose value is sufficiently large to safeguard the tube in

case the plate tank circuit L, C is detuned or greatly overloaded. While the biasing elements so far described are sufficient to safeguard the tube against any contingencies that might arise, the resulting bias in the case of proper adjustment of the amplifier stage would be too great to permit proper operation. Therefore, in accordance with the present invention, there is provided a circuit arrangement for reducing the total bias on the grid to a suitable value in the presence of proper grid excitation and plate circuit adjustment. In the illustrated form of the invention, a positive bias component is introduced whose magnitude increases with increasing load voltage. The circuit arrangement for achieving this result comprises a rectifier D which is inductively coupled by way of coil L_1 to the plate tank circuit coil L. A load resistance R_4 , together with radio frequency by-pass condenser K' is included in the circuit of rectifier D with the result that a positive voltage is developed across R_4 proportional to the alternating voltage across the load R_L and hence is a function of the power output of the stage. The negative end of resistor R_4 is grounded and the grid circuit return is connected by way of contact P to an adjustable point on R_4 . The total grid bias is thus reduced to a suitable operating value only in the presence of proper circuit adjustment. The amount of reduction in the grid bias in the presence of normal power output from the amplifier tube may be controlled by adjusting the coupling between coils L and L_1 as well as by adjustment of contact P, the coupling adjustment being slightly preferable because the resistance in the grid circuit is not affected thereby. It will, of course, be obvious that instead of the inductive coupling between coils L and L_1 , other means for coupling the plate tank circuit to the detector D may be employed, such as a capacitive connection.

The operation of the invention may be clarified by a description of the initial adjustment of the amplifier circuit. Without grid excitation, resistance R_3 is reduced to the lowest value which still limits the plate dissipation to the allowable amount. Then, with the load circuit R_L short circuited and full grid excitation applied, R_2 is reduced to the lowest value which will limit the plate dissipation to the allowable amount. Finally, with normal loading and proper plate circuit tuning, the setting of slider P, or preferably the coupling between L' and L, is adjusted to reduce the total bias on the grid to the point where normal operation of the amplifier is obtained. These adjustments are preferably made initially with reduced plate voltage, after which the plate voltage is gradually increased as the adjustments are repeated until full plate voltage is applied. When the adjustments have been carried out as

above indicated, the amplifier tube is safeguarded against nearly any contingency that might arise. For example, if grid excitation fails, the output voltage ceases and hence no positive bias is developed across R_4 and the space current through R_3 develops a bias which limits the plate dissipation as above explained. On the other hand, if excessive loading or a detuning of the output circuit occurs, the output voltage drops and the positive bias is reduced and the tube is safeguarded by the excitation self-bias developed across resistor R_2 as well as by the drop across R_3 .

In addition to its action in safeguarding against tube damage, the arrangement of the invention is advantageous for other purposes. For example, in the case of an amplifier for modulated radio frequency voltage, the constants of the circuit may be so adjusted as to make the bias of the amplifier stage vary throughout the modulation cycle in a predetermined manner so as to permit a larger carrier output than in the case of fixed bias operation. It will be understood that when modulated signals are to be amplified, condensers K and/or K' will be chosen small enough so that the component bias voltages developed across resistors R_3 and/or R_4 vary throughout the modulation cycle.

While I have described one form of the invention, it will be apparent to those skilled in the art that many modifications thereof may be employed within the scope of the following claims.

It should be understood that the ground connection shown in the drawing and mentioned in the claims is deemed to include any point of zero radio frequency potential.

What is claimed is:

1. In a radio frequency power amplifier tube circuit having grid and plate circuits, the method of operation which includes applying a first bias potential to said grid which is proportional to the grid current and sufficiently high to protect the tube from overheating in the event of plate circuit misadjustment, applying a second bias potential which is proportional to the space current in said amplifier and sufficiently high to protect the tube in the event of failure of grid excitation, and deriving from the alternating voltage in said plate circuit a third bias potential having a polarity in opposition to said first and second potentials and of such value as to reduce the total bias to a desired operating value in the presence of proper grid excitation and plate circuit adjustment.

2. In a radio frequency power amplifier tube circuit having grid and plate circuits, the method of operation which includes applying a first bias potential to said grid which is proportional to the grid current, applying a second bias potential which is proportional to the space current in said amplifier, and deriving from the alternating voltage in said plate circuit a third bias potential having a polarity in opposition to said first and second potentials, the relations of said three applied bias potentials being such as to cause the total bias to vary in a predetermined manner throughout a cycle of modulation of the excitation voltage.

3. A radio frequency power amplifier comprising a vacuum tube having a grid, a cathode and a plate, a first resistor connected between said

cathode and ground, a source of alternating current energy coupled to said grid and the grounded end of said resistor, a parallel tuned tank circuit coupled between said plate and the positive terminal of a source of direct current potential, a rectifier having a cathode and plate coupled to said tuned circuit, a second resistor connected in the space current path of said rectifier, the negative end of said last resistor being connected to ground, whereby a positive voltage is developed across said second resistor which is proportional to the voltage across said tuned circuit, and a direct current connection from a point intermediate the ends of said last resistor to said grid, said direct current connection including another resistor in series therewith, said resistors having such values as to permit operation of said power amplifier with full allowable plate excitation.

4. A radio frequency power amplifier comprising a vacuum tube having a grid, a cathode and a plate, a first resistor connected between said cathode and ground, a source of alternating current energy coupled to said grid and the grounded end of said resistor, a parallel tuned tank circuit coupled between said plate and the positive terminal of a source of direct current potential, a rectifier having a cathode and plate inductively coupled to said tuned circuit, a second resistor shunted by a condenser connected in the space current path of said rectifier, the negative end of said last resistor being connected to ground, whereby a positive voltage is developed across said second resistor which is proportional to the voltage across said tuned circuit, and a direct current connection from a point intermediate the ends of said last resistor to said grid, said direct current connection including another resistor in series therewith, said resistors having such values as to permit operation of said power amplifier with full allowable plate excitation.

5. A radio frequency power amplifier comprising a vacuum tube having a grid, a cathode and a plate, a first resistor connected between said cathode and ground, a source of alternating current energy coupled to said grid and the grounded end of said resistor, a parallel tuned tank circuit coupled between said plate and the positive terminal of a source of direct current potential, a rectifier having a cathode and plate inductively coupled to said tuned circuit, a second resistor shunted by a condenser connected in the space current path of said rectifier, the negative end of said last resistor being connected to ground, whereby a positive voltage is developed across said second resistor which is proportional to the voltage across said tuned circuit, and a direct current connection from a point intermediate the ends of said last resistor to said grid, said direct current connection being adjustable over said second resistor and including another resistor in series therewith, said resistors having such values as to permit operation of said power amplifier with full allowable plate excitation.

6. A radio frequency power amplifier in accordance with claim 3, characterized in this that the degree of coupling between said rectifier and said tuned circuit is adjustable.

WALTER VAN B. ROBERTS.