May 27, 1941. O. H. SCHADE 2,243,442

HIGH GAIN SIGNAL AMPLIFIER

Filed June 1, 1938

Fig. 1

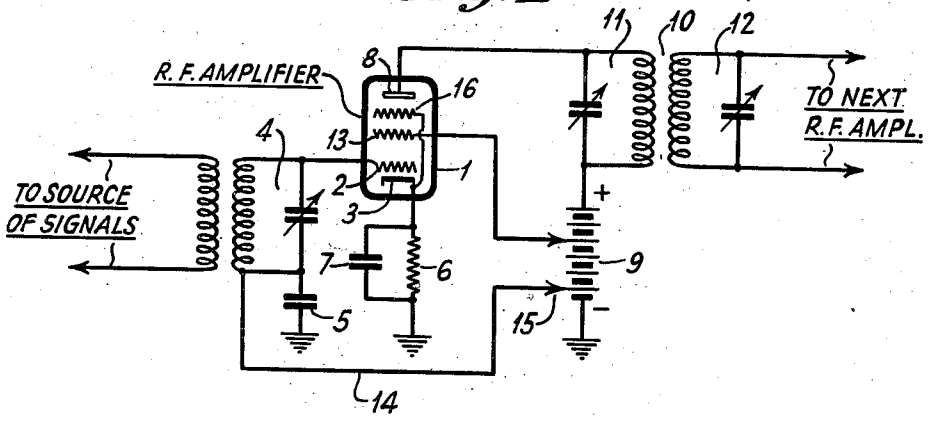
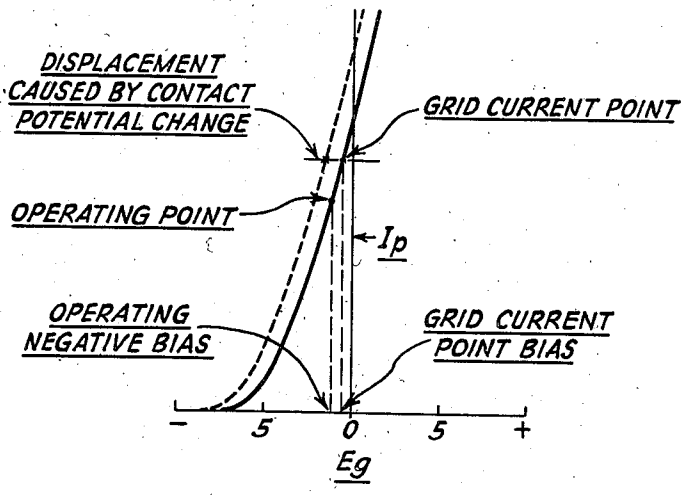


Fig. 2



INVENTOR.
OTTO H. SCHADE

BY H. S. Grover

ATTORNEY.

Patented May 27, 1941

2,243,442

UNITED STATES PATENT OFFICE

2,243,442

HIGH GAIN SIGNAL AMPLIFIER

Otto H. Schade, West Caldwell, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application June 1, 1938, Serial No. 211,155

2 Claims. (Cl. 179—171)

My present invention relates to high gain signal amplifier circuits, and more particularly to a novel method of, and means for, stabilizing the operating point of high mutual conductance amplifier tubes.

Self-bias circuits are used in radio frequency amplifiers to stabilize the operating point with respect to plate current. Such conventional self-bias circuits are not adequate to stabilize the plate current of amplifiers of the type using high mutual conductance tubes. This is particularly true of the latter when operated with negative signal grid bias voltage close to the grid current point. The advantage of the latter adjustment resides in the fact that the highest transconductance is secured with a given tube and a given plate current when the operating point (negative grid bias) is adjusted as close to the grid current point as the signal amplitude permits without grid current being drawn. For small signal amplitude amplifiers an operating point of about —0.2 volt, with respect to the grid current point, is entirely satisfactory, provided that it can be maintained at this position on the amplifier tube characteristic. With fixed bias, or conventional self-bias, arrangements such maintenance of the operating point is not possible. This is explained by the fact that the grid current point varies; the variation occurs at bias values from zero volts to —1.2 volts and depends on work-function, emission and temperature of the cathode and the value of the contact potential.

Accordingly, it may be stated to be one of the main objects of my present invention to prevent variations in the grid current point of an amplifier characteristic, which variations are due to inherent tube conditions, from affecting the value of the operating negative bias of the amplifier signal grid when the bias value is close to the grid current point; there being employed a combination of self-biasing and fixed bias arrangements in opposed polarity to establish the signal grid at a desired, effective signal grid bias value.

Another important object of this invention is to provide in a weak signal amplifier, of the type using a tube of high mutual conductance, a self-biasing network constructed to establish the signal grid at an abnormally high negative bias; a source of positive voltage of reasonably constant value being used to reduce the negative bias to a magnitude close to the amplifier tube grid current point.

Another object of my invention is to utilize a self-biasing resistor of relatively large magnitude in the cathode circuit of an amplifier tube of high mutual conductance whereby small changes in direct current voltages of the amplifier grid cause relatively small current changes in the resistor; a source of constant magnitude direct current voltage being connected to the grid to establish the effective grid bias value close to the grid current point of the tube characteristic but without drawing grid current.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows an amplifier circuit embodying the present invention,

Fig. 2 is the signal grid voltage-plate current characteristic of the amplifier tube in the circuit of Fig. 1, and showing the effect of the invention.

Referring now to Fig. 1, the numeral 1 denotes an amplifier tube of the pentode type; the tube may be of the 1851 type which has a g_m value of 10,000. Such a tube has an E_g—I_p characteristic as shown in Fig. 2, and, in general, its construction differs from the usual pentode tube in having its signal grid 2 much closer to the cathode 3. The tube has small thermal agitation noise, and is of particular advantage when used to amplify signals of small amplitude. For example, the source of signals impressed on tuned input circuit 4 may be the signal collector of a television receiver; in that case the tube 1 is employed as the radio frequency amplifier of the receiver. The grid 2 is connected to the high potential side of input circuit 4, while radio frequency bypass condensers 5 and 7 provide the signal connection path to the cathode.

The cathode 3 is grounded by a resistor 6 of high resistive value; the condenser 7 bypasses the resistor for radio frequency currents. Plate electrode 8 is connected to a voltage point on current source 9 which is at a desired positive value. The plate circuit includes the output network 10, and the latter may comprise tuned primary and secondary circuits 11 and 12. Circuits 4, 11, 12 are each tuned to the operating carrier frequency. Circuit 12 may feed the subsequent stages of the receiver. The screen electrode 13

is connected to a less positive potential point on current source 9, and the low potential end of circuit 4 is connected by lead 14 to a predetermined low positive potential point 15 of the current source 9.

The suppressor grid 16, which is at cathode potential, is disposed between the screen grid 13 and plate 8. A wider space is shown between signal grid 2 and screen grid 13 to depict in a purely qualitative manner the fact that this tube 1 has a high mutual conductance which is produced by positioning the grid 2 relatively close to cathode 3. When operating this amplifier circuit for the amplification of signals at radio frequency and of small amplitude, it is desirable to bias the grid 2 at a value of —0.2 volt negative with respect to the grid current point of the tube characteristic. This is more clearly shown in Fig. 2 wherein the E_g—I_p characteristic is shown and the operating negative bias point is illustrated as being more negative than the arbitrarily assumed grid current point. The highest transconductance is obtained when the negative grid bias is moved as close to the grid current point as the signal amplitude permits without allowing grid current to flow.

If the conventional self-biasing network were used in the cathode circuit, the potential difference between the grid current point and the operating point could not be maintained constant. Constancy would not result because of variations in the grid current point which occur at bias values from zero volts to —1.2 volts and which depend on work-function, emission and temperature of the cathode and contact potential value. According to this invention the potential difference between the grid current point and the operating negative bias point is maintained substantially constant by giving the resistor 6 a resistive magnitude which is large compared to

$$\frac{1}{g_m}$$

ohms for which the voltage drop across resistor 6 exceeds greatly the desired small bias value. The positive potential between ground and point 15 on current source 9 is used to reduce the voltage drop across resistor 6 to a value such that the grid 2 is biased by the small negative value desired. Such a circuit is highly degenerative to direct current voltage changes in the grid circuit, but not to alternating current voltage because of the bypass condenser 7. Small direct current changes of the grid 2 will have little effect on the current in resistor 6 because of the large resistance value of the latter. Hence, the operating point of the tube 1 is stabilized at a predetermined current value.

To illustrate the advantage which is secured by means of the present invention, let it be assumed that tube 1 has a mutual conductance of 10,000; a value of —0.8 volt for E_g; a value of 10 ma. for I_p; and a grid current point E_0 of —0.6 volt. Also, assume that a self-bias resistor of 80 ohms is employed. If, now the effect of contact potential is to change the grid current point to —1 volt, it can be shown that the new bias voltage becomes —0.98 volt, and the operating point is then in the grid current range, while the plate current rises to 12.2 ma. If now the bias resistor, according to this invention, is given a value equal to

$$\frac{1}{g_m}$$

or 1,000 ohms, the new bias E_g equals —1.16 volts. It will thus be seen that the grid current point E_0 is approached only 0.04 volt closer, and the plate current has only increased to 10.4 ma. The effect then of using a self-bias resistor of relatively high magnitude is to minimize variation of the grid bias value with respect to the grid current point, while permitting the tube to operate with maximum transconductance for small signal amplification.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In a radio frequency amplifier circuit of the type employing a tube having at least a cathode, signal grid and plate, and which tube is constructed to have a relatively high mutual conductance, a signal input circuit connected between the signal grid and cathode, a resistor in the cathode circuit which has a high resistive magnitude which is much larger than the reciprocal of the said conductance thereby providing an abnormally high negative bias for the signal grid, a signal output circuit connected between the cathode and said plate, and means, connected solely between the low potential end of the input circuit and the low potential end of the said resistor, providing a positive potential difference between the signal grid and cathode in opposition to said abnormally high negative bias to reduce the effective grid bias to a small negative value with respect to the tube characteristic grid current point whereby the tube operates with maximum transconductance for weak signal amplification without drawing grid current.

2. In a weak signal amplifier circuit, a tube of the pentode type having a cathode, signal grid, screen grid, suppressor grid and plate in the order named, said signal grid being positioned sufficiently close to the cathode to impart a high mutual conductance to the tube, a signal input circuit connected between the signal grid and cathode, a signal output circuit connected to the plate, a resistor in the space current path of the tube whose magnitude is large compared to the reciprocal of said conductance value whereby an abnormally high negative bias is provided for the signal grid, means in circuit solely between the low potential side of the input circuit and the low potential end of said resistor for reducing the high bias to a small negative value with respect to the tube characteristic grid current point, and said small value being sufficiently close to said grid current point to permit the tube to operate with maximum transconductance without drawing grid current.

OTTO H. SCHADE.