July 18, 1933. P. O. FARNHAM 1,919,160

RADIO RECEIVING SYSTEM

Filed Nov. 4, 1932

FIG. 1.

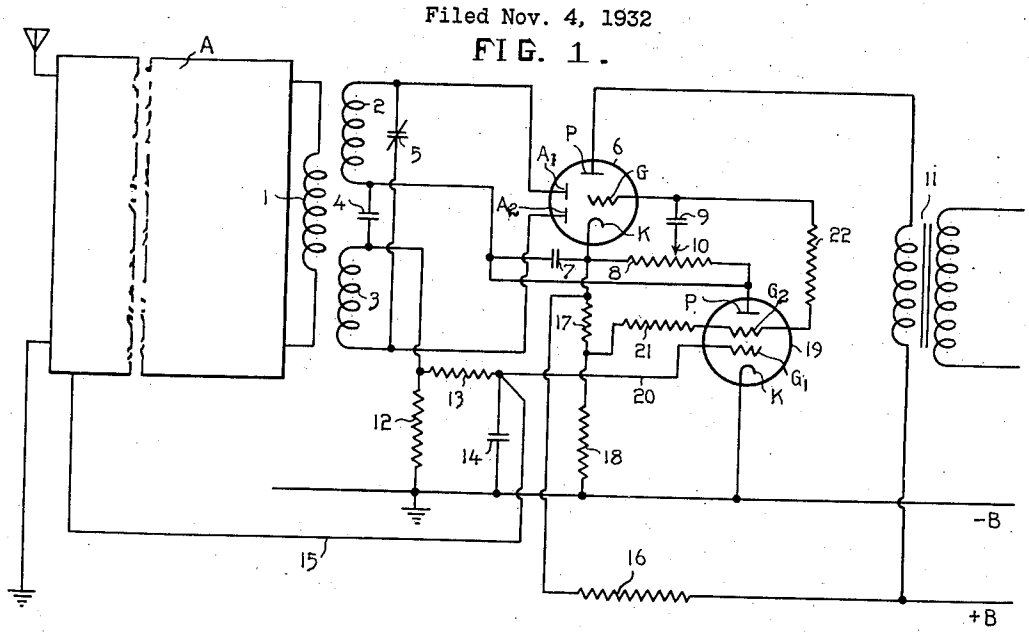
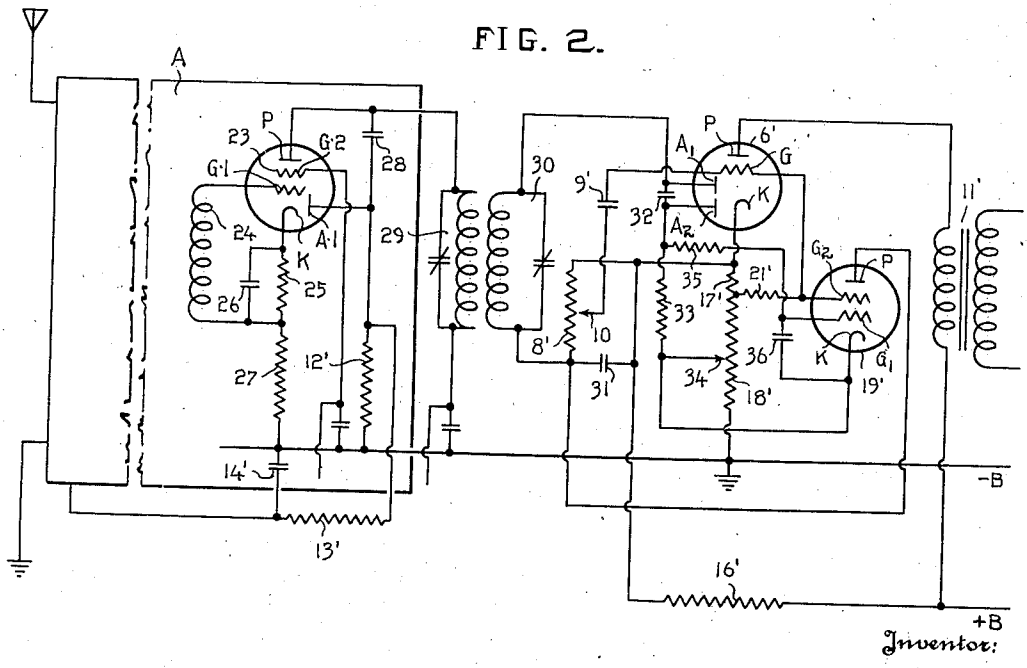


FIG. 2.



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UNITED STATES PATENT OFFICE

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RADIO RECEIVING SYSTEM

Application filed November 4, 1932. Serial No. 641,278.

This invention relates to radio receiving systems of the automatic gain control type, and particularly to methods of and circuit arrangements for suppressing all output from the receiver when the amplitude of the carrier wave to which the system is tuned falls below a predetermined value.

Various methods and circuit arrangements for accomplishing this general result are described and claimed in my copending applications Ser. No. 524,383, filed March 21, 1931, Ser. No. 585,593, filed January 8, 1932, and Ser. No. 603,849, filed April 7, 1932. As explained in those applications, it is highly desirable to suppress intercarrier noise in receivers, particularly those equipped with automatic gain control. It will here be sufficient to recall the fact that the sensitivity of a high gain receiver employing the commonly used automatic gain control system becomes so great, when the system is tuned to a frequency at which only a weak carrier wave or none at all is received, that the amplified receiver noise rises to levels that are quite intolerable at the loud speaker output.

Objects of the present invention are to provide, in a radio receiver system, improved methods of and circuit arrangements for automatically eliminating this "noise" output, and in fact all output, when the amplitude of the carrier wave to which the receiver system is tuned falls below a given value, i. e., below the "noise level".

Further objects are to provide methods and circuit arrangements for obtaining the stated results with a minimum of circuit elements and tubes. More particularly, objects are to provide radio receiver systems of the noise suppression type, and which are characterized by the employment of a vacuum tube of new design and associated circuit elements for effecting the noise suppression action by circuits that perform the function of automatic gain control, the tube being of the multiple element type and including elements for diode rectification and for amplification.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawing, in which:

Figs. 1 and 2 are fragmentary circuit diagrams of radio receiver systems embodying the invention.

The form of the invention which is shown in Fig. 1 is adapted for automatic noise suppression in conjunction with the operations of detection and automatic gain control, but does not include any adjustment for controlling the relative carrier levels required for noise suppression and for automatic gain control.

In the drawing, the reference character A identifies a radio amplifier, including one or more vacuum tubes, which receives carrier wave energy from an appropriate collector structure, and which works into a detector and audio amplifier or other load circuit. The exact design and construction of these elements are not a part of the invention and any desired type of tuned radio frequency or superheterodyne amplifier may be employed.

The output coil 1 of the last tube of the amplifier A applies the amplified radio voltage, which will be of intermediate frequency in the case of a superheterodyne amplifier, to the tuned input circuit composed of the coils 2, 3, the fixed condenser 4 and the tuning condenser 5. The fixed condenser serves as a blocking condenser for direct current and is large in comparison to the tuning condenser.

The radio voltages developed across the coils of the input system are applied to the separate anodes of a tube 6 of the type known commercially as "type 55", and which include a cathode K, anodes A_1 and A_2 which cooperate with cathode K to form two diode rectifiers, and a grid G and plate P which cooperate with the cathode to form a triode amplifier. The inner terminals of coils 2 and 3, i. e., those connected to the blocking condenser 4 have substantially the same radio voltage, and, for convenience of description, the outer terminals of coils 2, 3 will be termed the high potential terminals of those coils.

The high potential terminal of coil 2 is connected to the anode A_1, and the inner or low potential terminal is connected directly, but for radio voltages only, to the cathode K by the condenser 7. For direct current,

however, the low potential terminal of coil 2 is connected to the cathode K through the resistance 8. These circuit elements constitute a diode detector, and any desired portion of the audio frequency voltage developed across the resistance 8 is transferred to the grid G through an audio frequency condenser 9 and an adjustable tap 10 which serves as a manual control of the output level of the system.

The output circuit of the triode elements of tube 6 is shown as a transformer 11 which has its primary connected between plate P and a source, indicated as +B, of direct current potential.

The outer or high potential terminal of the input coil 3 is connected to the anode A_2 and the inner terminal of the coil is connected to ground through the resistance 12. The cathode K is connected to ground (through resistances as will be described hereinafter) and therefore the described circuit elements constitute a diode rectifier, the direct current voltage developed across resistance 12 being applied, through a filter comprising a resistance 13 and condenser 14, and a lead 15, to the amplifier A as a gain control bias.

The cathode K is connected to the source +B of direct current potential through a resistance 16, and is connected to ground through the series resistances 17, 18. These resistances constitute a voltage divider which places the cathode K at a fixed positive potential with respect to anode A_2, thereby preventing the development of a rectified or gain control voltage until the peak radio voltage across coil 3 exceeds the negative bias on the anode A_2. This is highly desirable in automatic gain control systems as it avoids loss of sensitivity for received carrier voltages below that level which, at maximum gain, will develop the normal output of the system.

As the two diode rectifiers work upon alternate halves of the amplified wave, this delay action of the gain control rectifier has substantially no effect upon the wave impressed upon the detector. This method and circuit arrangement for avoiding distortion is described and claimed in my application Ser. No. 611,402, filed May 14, 1932.

A direct current amplifier tube 19, of the screen grid type, and its associated circuit elements serve as the means for suppressing all receiver output for received carrier waves of less than a predetermined amplitude. The control grid G_1 of the tube 19 is connected by lead 20 to the output terminal of the resistance 13 of the filter system of the gain control rectifier. The screen grid G_2 is connected by resistance 21 to the junction of resistances 17, 18 in the cathode circuit of tube 6, and through resistance 22 to the control grid G of the triode amplifier elements of tube 6. The junction of the detector input coil 2 and the audio output resistance 8 is connected to the plate P of tube 19.

In the absence of received carrier waves, the potentials applied to the direct current amplifier 19 are derived solely from the direct current source +B, and an appreciable current flows in the plate and screen grid circuits. Current flow in the plate circuit of tube 19 produces a voltage drop across resistance 8 which places the cathode K at a positive potential with respect to the detector anode A_1. Similarly, current flow in the screen grid circuit increases the negative bias on grid G of tube 6 above that value which is determined by the voltage drop across the cathode resistance 17. Under these conditions a relatively low value of modulated radio voltage across coil 2 will not produce an audio frequency voltage across resistance 8 as a high negative bias is impressed upon the detector anode A_1 and, if an audio voltage is developed across resistance 8, it will not be amplified by the triode elements of tube 6 since the grid G is subjected to a high negative bias.

When the received carrier energy rises above the noise level, the diode rectifier formed by anode A_2 and cathode K comes into action, i. e., when the peak radio voltage across coil 3 exceeds the negative bias due to the voltage drop across resistances 17, 18. When a direct current voltage is developed across resistance 12, a negative potential is applied to the control grid G_1 of tube 19 and the space current flow in that tube is reduced or cut off. When this occurs, the reduction or suppression of plate current flow through resistance 8 removes the negative bias on the detector elements A_1, K, and an audio frequency voltage is thereby developed across resistance 8. Simultaneously, the reduction or suppression of current flow in the screen grid circuit of tube 19 reduces the negative bias on grid G of the triode, and the audio voltage impressed on grid G is amplified in the plate circuit. So long as the received carrier energy is below that value which results in rectification by the gain control rectifier A_2, K, all audio output is suppressed by the blocking of the detector and the audio amplifier. As the received carrier energy rises above the critical value, the blocking bias voltages are removed from the detector and audio amplifier elements of tube 6 and the receiver system functions in the usual manner as an automatic gain control receiver for holding the audio output substantially independent of variations in received carrier energy. In other words, all audio output is suppressed when the received energy is below a predetermined critical value and, when the received energy is of sufficient magnitude to produce a proper audio signal, all bias voltages which effect the noise suppres-

sion are removed and the normal amplifier and detector action takes place.

Suitable values of some of the circuit elements and energizing potentials are:

Resistor 8=100,000 ohms.
Resistor 12=1 megohm.
Resistor 13=0.5 megohm.
Resistor 16=11,000 ohms.
Resistor 17=500 ohms.
Resistor 18=1,250 ohms.
Resistor 21=100,000 ohms.
Resistor 22=1 megohm.
Condenser 4=.01 microfarads.
Condenser 7=100 micromicrofarads.
Condenser 9=.01 microfarads.
Condenser 14=.05 microfarads.
+B lead=200 volts positive to −B.

In the operation of the circuit shown in Fig. 1, there is no provision for any adjustment of the critical voltage level at which the automatic gain control comes into action and the noise suppression bias voltages are removed. The circuit shown in Fig. 2 includes adjustable circuit elements for independently adjusting the critical input levels of the noise suppression system and the automatic gain control.

An independent diode for automatic volume control is provided in the Fig. 2 circuit by an extra anode A_1 in the last tube 23 of the radio frequency amplifier A; the extra anode operating with the common cathode but being located outside of the range of influence of the remaining electrodes of a conventional screen grid amplifier tube.

The input or coupling coil 24 is connected to the control grid G_1 and to the cathode K through the bias resistor 25 which is shunted by a condenser 26. A resistor 27 is connected between resistor 25 and ground to place the cathode K at a more positive potential than that of the anode A_1 which is connected to ground through the direct current output resistance 12′. The amplified radio frequency voltage developed by the amplifier elements of the tube 23 is impressed upon this diode rectifier through the condenser 28 which is connected to the anode A_1 and to the tuned output circuit 29 of the amplifier. When the received radio frequency voltage rises above the critical value determined by the potential drop across the series resistors 25, 27, rectification takes place and the voltage across resistor 12′ is applied to the control grids of the preceding tubes through the filter formed by resistance 13′ and condenser 14′. The multiple function detector stage tube 6′ is of the same "55" type as that shown in Fig. 1, and the input circuit 30 is connected between the anode A_1 and, for alternating current only, directly to the cathode K through the radio frequency by-pass condenser 31. For direct current, the low potential terminal of the input circuit 30 is connected to the plate P of the direct current amplifier 19′. The audio frequency voltage developed across the output impedance 8′ of this diode detector is impressed upon the control grid G of tube 6′ through the blocking condenser 9′ and the adjustable tap 10′ which provides a manual control of the audio output level.

The noise suppression diode rectifier has its anode A_2 connected to the input circuit 30 through the blocking condenser 32 and the direct current output resistance 33 of this diode is connected by an adjustable tap 34 to the series resistances 17′, 18′ in the cathode circuit. The adjustable tap 34 permits a control of the negative bias on anode A_2 and the adjustment of this tap determines the critical radio frequency voltage below which the detector and audio amplifier are rendered inoperative by the action of the tube 19′.

The control grid G_1 of the tube 19′ is connected to anode A_2 by resistance 35 and to the cathode K through an audio frequency condenser 36. As in the Fig. 1 circuit, the screen grid G_2 is connected to the junction of resistances 17′, 18′ by a resistance 21′, and is connected to the control grid G of the tube 6′. The cathode K of tube 6′ is connected through a resistance 16′ to a point of positive potential +B, and the plate circuit of tube 6′ includes the primary of an audio frequency transformer 11′ and the plate current source +B. In general, operation of this circuit will be apparent from the description of the Fig. 1 circuit. By means of the adjustable tap 34, the audio output from tube 6′ may be cut off for radio frequency levels below any predetermined limit, which limit is preferably less than that required to bring the automatic gain control diode elements A_1 and K of tube 23 into action. This independent control of the noise suppression system is particularly desirable as it permits adjustment of the receiver to meet the particular noise interference conditions at the locality in which the receiver is to be operated.

A separate adjustment of the critical voltage at which the automatic volume control becomes operative may be had by making the resistor 27 adjustable but, in general, this regulation is neither necessary nor desirable, since the operating characteristics of the automatic volume control are determined by the receiver design and not by conditions peculiar to any one locality.

I claim:

1. In a radio receiver, the combination of a multiple function tube having therein the elements of an amplifier and two rectifiers, input circuit elements for impressing radio frequency voltages upon both rectifiers, an audio frequency output circuit for one rectifier, means coupling the input circuit of the amplifier to said audio frequency output circuit, a direct current output circuit for the second rectifier, and means energized by the rectified voltage developed in said direct cur-

rent output circuit for controlling the operation of said first rectifier.

2. In a radio receiver, the combination of a multiple function tube having therein the elements of an amplifier and two rectifiers, input circuit elements for impressing radio frequency voltages upon both rectifiers, an audio frequency output circuit for one rectifier, means coupling the input circuit of the amplifier to said audio frequency output circuit, a direct current output circuit for the second rectifier, and means energized by the rectified voltage developed in said direct current output circuit for controlling the operation of said amplifier.

3. In a radio receiver, the combination of a multiple function tube having therein the elements of an amplifier and two rectifiers, input circuit elements for impressing radio frequency voltages upon both rectifiers, an audio frequency output circuit for one rectifier, means coupling the input circuit of the amplifier to said audio frequency output circuit, a direct current output circuit for the second rectifier, and means energized by the rectified voltage developed in said direct current output circuit for suppressing substantially all output from said amplifier when the impressed carrier voltage falls below a predetermined value.

4. In a radio receiver, the combination with a tube having two anodes, a control grid, plate and cathode, of input circuit elements for impressing radio frequency voltages between each anode and the cathode, circuit elements cooperating with one anode and the cathode to form the output circuit of a diode detector, an input connection from the control grid to said output circuit, an audio frequency load in circuit with said plate and cathode, a direct current output circuit for the diode formed by said cathode and second anode, and means actuated by the direct current voltage developed in said direct current output circuit for controlling the operation of said detector diode.

5. In a radio receiver, the combination with a tube having two anodes, a control grid, plate and cathode, of input circuit elements for impressing radio frequency voltages between each anode and the cathode, circuit elements cooperating with one anode and the cathode to form the output circuit of a diode detector, an input connection from the control grid to said output circuit, an audio frequency load in circuit with said plate and cathode, a direct current output circuit for the diode formed by said cathode and second anode, and means actuated by the direct current voltage developed in said direct current output circuit for controlling the operation of the audio frequency amplifier formed by said cathode, control grid and plate.

6. In a radio receiver, the combination with a tube having two anodes, a control grid, plate and cathode, of input circuit elements for impressing radio frequency voltages between each anode and the cathode, circuit elements cooperating with one anode and the cathode to form the output circuit of a diode detector, an input connection from the control grid to said output circuit, an audio frequency load in circuit with said plate and cathode, a direct current output circuit for the diode formed by said cathode and second anode, and means actuated by the direct current voltage developed in said direct current output circuit for controlling the bias voltage impressed upon said detector diode.

7. In a radio receiver, the combination with a tube having two anodes, a control grid, plate and cathode, of input circuit elements for impressing radio frequency voltages between each anode and the cathode, circuit elements cooperating with one anode and the cathode to form the output circuit of a diode detector, an input connection from the control grid to said output circuit, an audio frequency load in circuit with said plate and cathode, a direct current output circuit for the diode formed by said cathode and second anode, and means actuated by the direct current voltage developed in said direct current output circuit for controlling the bias voltage impressed upon the audio frequency amplifier formed by said cathode, control grid and plate.

8. In a radio receiver, the combination with a tube having two anodes, a control grid, plate and cathode, of input circuit elements for impressing radio frequency voltages between each anode and the cathode, circuit elements cooperating with one anode and the cathode to form the output circuit of a diode detector, an input connection from the control grid to said output circuit, an audio frequency load in circuit with said plate and cathode, a direct current output circuit for the diode formed by said cathode and second anode, means impressing bias voltages upon said diode detector and upon said amplifier to render the same inoperative, and means including said second rectifier for automatically removing said bias voltages when the received radio frequency voltage exceeds a predetermined value.

9. The invention as set forth in claim 8, wherein said last means includes an amplifier tube for amplifying direct current voltages developed by the rectifier action of said cathode and second anode.

10. The invention as set forth in claim 8, wherein said last means includes a screen grid amplifier tube for amplifying direct current voltages developed by the rectifier action of said cathode and second anode, the screen grid and plate circuits of said screen grid amplifier tube including resistances which are connected between said cathode

and, respectively, the first anode and the control grid of said first tube.

11. In a radio receiver, the combination with a radio frequency input circuit, an audio frequency output circuit, of a multiple function tube housing the elements of two diode rectifiers and an amplifier, said rectifiers being coupled to said input circuit, an audio frequency output circuit for one rectifier, adjustable means for impressing upon the said amplifier a desired portion of the audio frequency voltage developed in the output circuit of said first rectifier, a direct current output circuit for said second rectifier, and means energized by the rectified output of said second rectifier for controlling the flow of alternating current in one of said audio frequency output circuits.

12. The invention as set forth in claim 11, in combination with means for impressing on one of said rectifiers a bias voltage to render the same inoperative for radio frequency voltages below a predetermined critical value.

13. The invention as set forth in claim 11, in combination with means impressing upon each rectifier a bias voltage which renders the same inoperative for radio frequency voltages below predetermined critical values, and wherein the said means energized by the rectified output of the second rectifier removes the bias voltage from said first rectifier when the radio frequency voltage rises above the predetermined value at which said second rectifier becomes operative to pass a rectified current.

14. In a radio receiver, the combination with a tube having an anode, a control grid, plate and cathode, of a radio frequency amplifier, means cooperating with said anode and cathode to form a diode detector working out of said amplifier, means for automatically controlling the gain of said radio frequency amplifier, circuit elements for impressing upon said control grid an audio frequency voltage developed by said diode detector, an audio frequency load in the plate circuit of said tube, means establishing a bias voltage between cathode and another tube element to suppress the transmission of audio frequency currents by said tube, and means operable automatically when the received radio frequency voltage rises above a critical level to reduce the bias voltage to permit normal transmission by said tube.

15. The invention as set forth in claim 14, wherein said bias reducing means includes said means for automatically controlling the gain of said amplifier.

16. The invention as set forth in claim 14, wherein said means for automatically controlling the gain of said amplifier includes a second anode within said tube and cooperating with said cathode to form a diode rectifier.

17. The invention as set forth in claim 14, wherein said means for automatically controlling the gain of said amplifier includes a second anode within said tube and cooperating with said cathode to form a diode rectifier, and said bias reducing means includes a direct current amplifier working out of said diode rectifier.

18. In a radio receiver, a radio frequency amplifier, a multiple function tube including a diode detector and an audio frequency amplifier, circuit elements connecting said detector between said radio frequency amplifier and said audio amplifier, means for controlling the gain of said radio frequency amplifier, and means independent of said gain control means for automatically suppressing transmission of audio frequency signals by said tube when the radio frequency voltage impressed on said detector falls below a predetermined value.

19. The invention as set forth in claim 18, wherein said transmission suppression means includes means impressing upon one element of said tube a bias voltage effective to prevent transmission of audio frequency voltages thereby, and means including a diode rectifier for reducing the said impressed bias voltage when the radio frequency voltage on said detector exceeds the predetermined value.

20. The combination with a multiple function tube housing the elements of a diode detector, a diode rectifier, and an amplifier, of circuit elements forming a radio frequency input circuit for said detector and rectifier, circuit elements coupling said amplifier to the audio frequency output circuit of said detector, means biasing said detector and said amplifier to render the same inoperative, and means energized by the rectified output of said rectifier when the radio frequency voltage impressed thereon exceeds a predetermined value for removing the bias voltages which render the detector and amplifier inoperative.

PAUL O. FARNHAM.

DISCLAIMER

1,919,160.—*Paul O. Farnham*, Boonton, N. J. RADIO RECEIVING SYSTEM. Patent dated July 18, 1933. Disclaimer filed October 25, 1935, by the assignee, *Radio Corporation of America*.

Hereby enters this disclaimer to the said claims of said Letters Patent which are in the following words, to wit:

"14. In a radio receiver, the combination with a tube having an anode, a control grid, plate and cathode, of a radio frequency amplifier, means cooperating with said anode and cathode to form a diode detector working out of said amplifier, means for automatically controlling the gain of said radio frequency amplifier, circuit elements for impressing upon said control grid an audio frequency voltage developed by said diode detector, an audio frequency load in the plate circuit of said tube, means establishing a bias voltage between cathode and another tube element to suppress the transmission of audio frequency currents by said tube, and means operable automatically when the received radio frequency voltage rises above a critical level to reduce the bias voltage to permit normal transmission by said tube."

"16. The invention as set forth in claim 14, wherein said means for automatically controlling the gain of said amplifier includes a second anode within said tube and cooperating with said cathode to form a diode rectifier."

[*Official Gazette November 19, 1935.*]