

June 8, 1937.

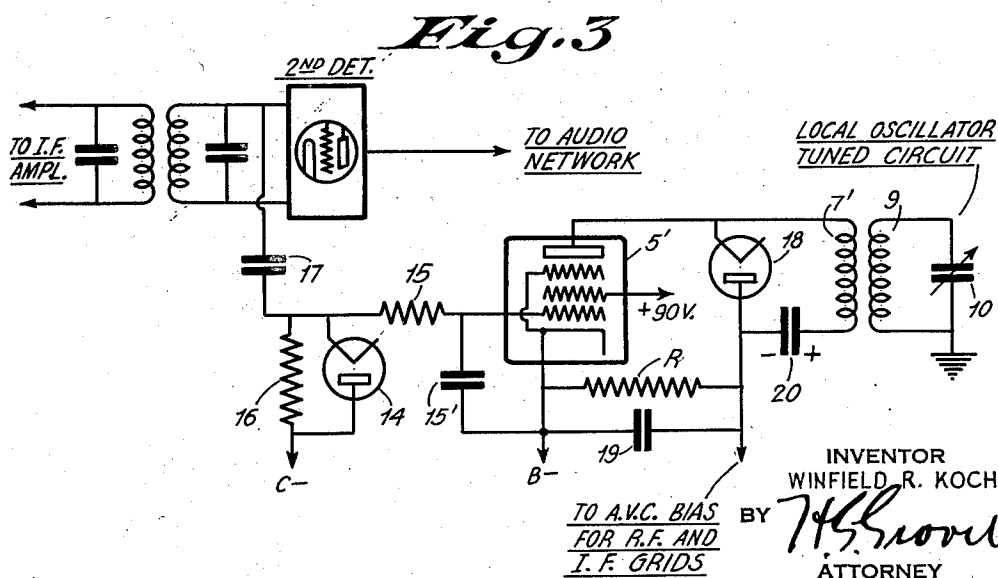
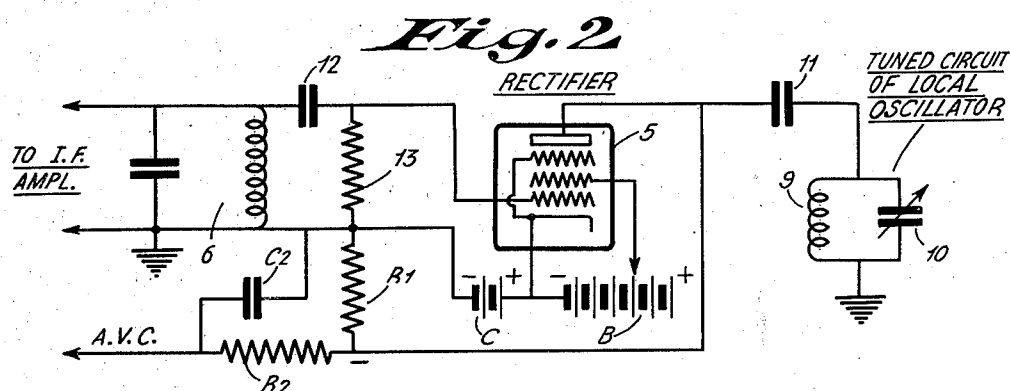
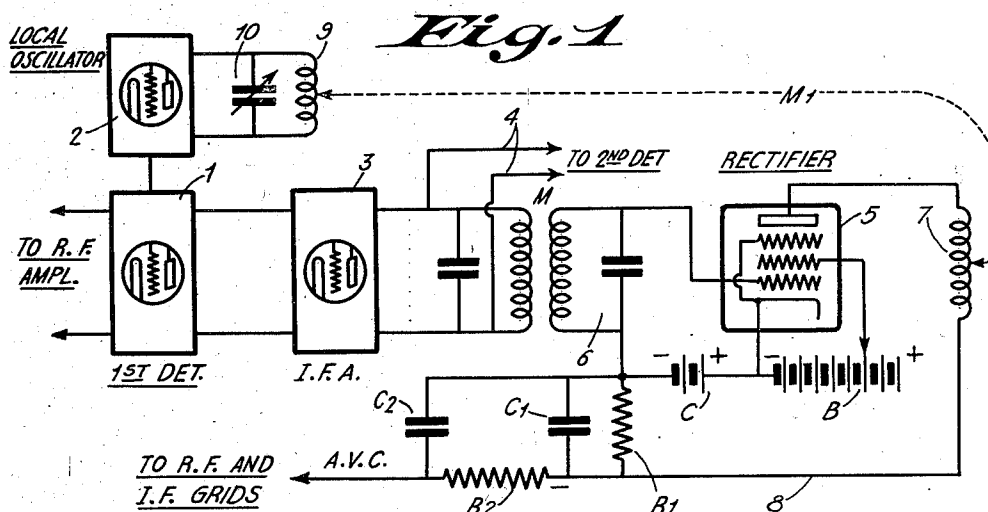
W. R. KOCH

2,082,961

AUTOMATIC GAIN CONTROL CIRCUIT

Filed July 6, 1934

2 Sheets-Sheet 1



June 8, 1937.

W. R. KOCH

2,082,961

AUTOMATIC GAIN CONTROL CIRCUIT

Filed July 6, 1934

2 Sheets-Sheet 2

Fig. 4

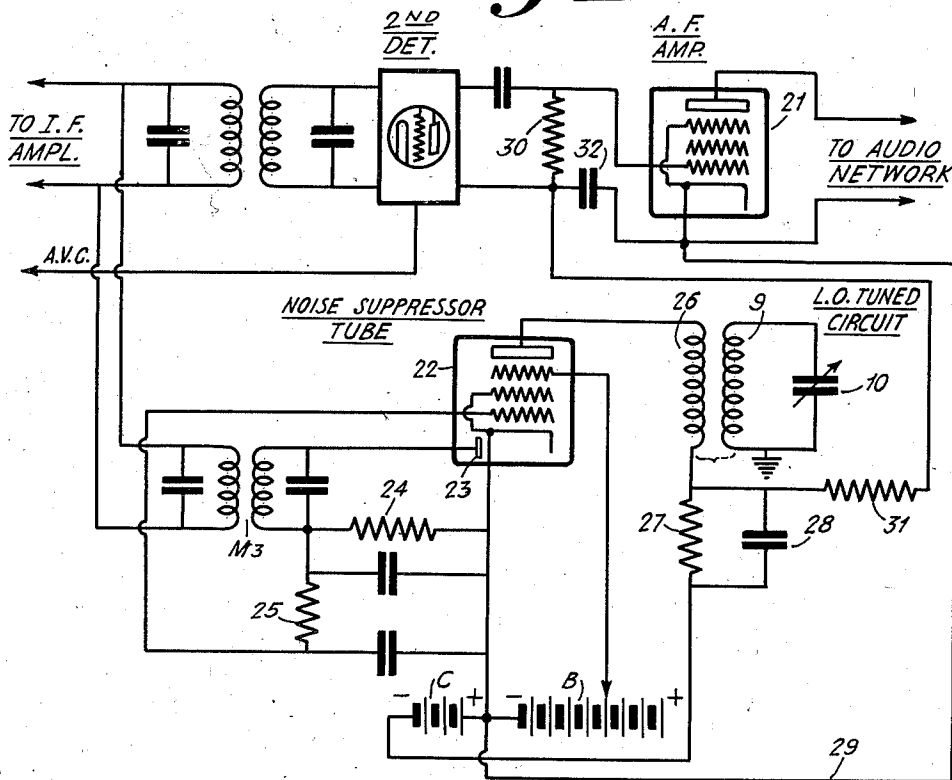
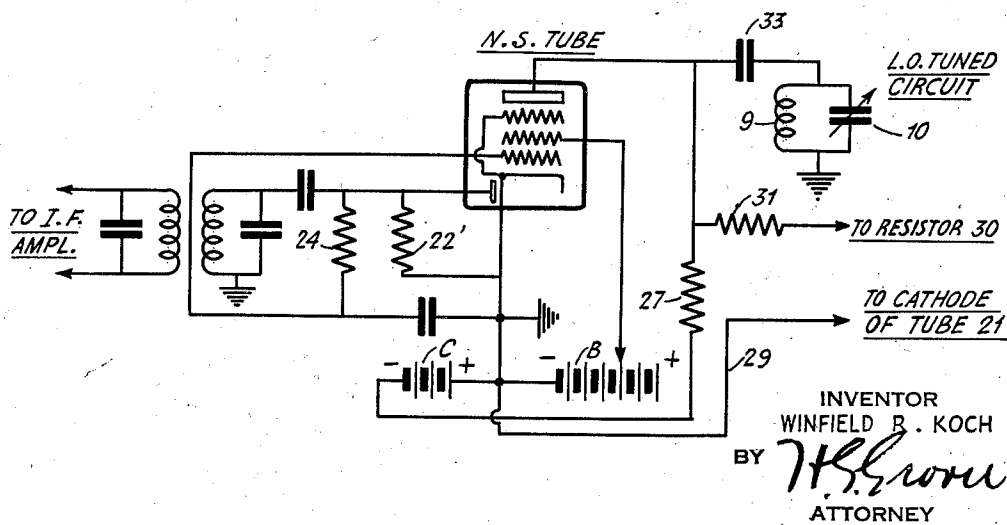


Fig. 5



INVENTOR
WINFIELD B. KOCH
BY *W. H. Brown*
ATTORNEY

UNITED STATES PATENT OFFICE

2,082,961

AUTOMATIC GAIN CONTROL CIRCUIT

Winfield R. Koch, Camden, N. J., assignor to
Radio Corporation of America, a corporation
of Delaware

Application July 6, 1934, Serial No. 733,987

12 Claims. (Cl. 250—20)

My present invention relates to gain control circuits, and more particularly to such circuits when utilized for automatic volume control.

One of the main objects of the present invention is to provide automatic gain control circuits for amplifiers, whether of high frequency or audible frequency, which circuits embody control tubes having output electrodes adapted to be energized by alternating current energy, the alternating current energy being of local oscillation frequency.

Another important object of the present invention is to provide automatic volume control circuits for radio receivers wherein the automatic volume control tubes may have their plates energized by alternating current energy, in place of the usual direct current sources, and the alternating current energy being derived from an existent source in the receiver, such as the tunable local oscillator circuit of a superheterodyne receiver.

Still other objects of the invention are to improve generally the efficiency of automatic gain control circuits for radio receivers, and more especially to provide in radio receivers automatic volume control circuits, and in some instances interchannel noise suppressor circuits, which are not only reliable in operation, but readily assembled in a radio receiver.

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, both as to its organization and method of operation, will best be understood by reference to the following description taken in connection with the drawings, in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect. In the drawings:—

Fig. 1 diagrammatically shows an automatic volume control system embodying one form of the invention,

Fig. 2 shows a modification,

Fig. 3 shows still another modification,

Fig. 4 shows an automatic volume control system embodying an interchannel noise suppressor circuit according to the present invention,

Fig. 5 shows a modified interchannel noise suppressor circuit.

Referring now to the accompanying drawings, wherein like reference characters in the different figures correspond to similar circuit elements, there is shown in Fig. 1 an automatic volume control system for a superheterodyne receiver particularly. It is to be clearly understood that

the nature of the receiver with which the volume control network is associated is of comparatively little importance as far as the present application is concerned. The superheterodyne type of receiver has been employed as an illustration because it is at the present time substantially universally employed in broadcast reception in the United States and in many foreign countries. For this reason the various networks of the receiver are conventionally shown in Fig. 1, and it will be observed that the numeral 1 designates a first detector upon which is impressed energy of local oscillation frequency from a local oscillator 2. The intermediate frequency output of the network 1 is impressed upon an intermediate frequency amplifier 3.

The signal input circuit to the first detector may be connected to a signal collector, or to one or more stages of tuned radio frequency amplification. The amplified output of network 3 is then impressed upon a second detector, or audio demodulator, through leads 4. The demodulated energy is utilized in one or more stages of audio amplification, and then finally reproduced. The receiving system could be employed as a portable receiver in an automobile, or in a cabinet in the home of the user. The operating range of the receiver can be in the broadcast range, or the receiver may be of the multi-range variety, and in that case it could also be operated in the various short wave bands outside the broadcast band.

The automatic volume control system is utilized in the receiver, as is well known at the present time, in order to maintain a substantially constant carrier energy level at the input of the audio demodulator. Because of fading phenomena, or other causes which result in effects analogous to fading, the signal energy level at the audio demodulator tends to fluctuate. The automatic volume control system overcomes this tendency, and for this reason is utilized in modern radio receivers. The automatic volume control network shown in Fig. 1 embodies a tube 5 which is of the pentode type, and its resonant input circuit 6 is connected between its signal grid and cathode. The resonant input circuit 6 is coupled to the resonant output circuit of the intermediate frequency network 3, and the coils of both resonant circuits may comprise the primary and secondary windings of the coupling transformer M.

The voltage source B is employed to provide positive potential for the screen grid of tube 5, and the voltage source C furnishes negative bias

for the signal grid of tube 5. The plate of the pentode tube is connected to the low alternating voltage side of input circuit 6 through a path which includes the secondary winding 7 of the transformer M₁, lead 8 and resistor R₁, a by-pass condenser C₁ being connected in shunt across resistor R₁. A resistor R₂ is connected to the lead 8, and is arranged in series with coil 7, a by-pass condenser C₂ being connected in shunt across resistors R₁ and R₂. The primary winding 9 of transformer M₁ has a tuning condenser 10 connected across it.

The circuit 9—10 is the tunable local oscillator circuit of the local oscillator 2, and the variable condenser 10 is, of course, mechanically uni-controlled with the variable tuning condensers of the first detector and radio frequency amplifier stages in a manner well known to those skilled in the art. The symbol M₁ has been shown disposed between dotted line arrows coupling coils 9 and 7, and it will be understood that these two coils are magnetically coupled so that local oscillator energy may be impressed upon the coil 7. The physical connection between these two coils may be made in any desired manner, and these coils may be the actual windings of a transformer, or a link circuit may be used to couple them.

The tube 5 functions as the AVC rectifier, and derives its signal energy from the output of the intermediate frequency amplifier. For this reason the input circuit 6 is fixedly tuned to the operating intermediate frequency. Instead of using a separate source of direct current voltage for the plate of the tube 5 which produces the control voltage for gain control, the tube is operated with alternating current on the plate. The alternating current is obtained from a source present in the receiver, and it will be observed that this source is the local oscillator. This permits the utilization of common A, B and C battery operation, and no more than the usual voltage need be used. Thus, AVC voltage requirements are simplified, and improved AVC is permitted with a battery operated receiver, such as used in sections where power lines are not available, or in automobiles.

The rectifier 5 is normally biased somewhat more negative than is required to reduce the plate current to zero. When a signal is tuned in, the intermediate frequency energy impressed on the signal grid of rectifier tube 5 will cause the plate current to flow, and this will make the plate end of resistor R₁ more negative. In turn, this increases the bias on the amplifier tubes to control the amplification of the signal energy. The lead connected to the negative end of resistor R₁ has been designated AVC to denote the direct current gain control connection to the grids of the various controlled amplifier tubes. It is to be clearly understood that the AVC connection may be made to the various radio frequency amplifier tubes, the intermediate frequency amplifier tubes, and, if desired, to the first detector tube as well. The alternating current components are filtered out from the control bias voltage derived across resistor R₁ through a filter network including resistor R₂ and condenser C₂. Of course, the same batteries used for the control rectifier 5 may be utilized for the remainder of the tubes in the receiver. If an alternating current operated receiver is utilized, the B and C batteries may be replaced by the resistor across the output of the rectifier and filter.

The tube 5, using alternating current on the plate, really functions only during part of the cycle. During the half cycle in which the end of the transformer winding 7 nearest the plate of the tube 5 is negative, no current can flow. During the following half cycle, this end of the winding becomes positive, and current will flow, provided the grid is not too negative, and condenser C₁ will be charged up.

The arrangement in Fig. 1 shows an arrangement wherein a series feed is provided for the plate of the AVC rectifier tube 5. In Fig. 2 there is shown a similar circuit arrangement differing from that shown in Fig. 1 only insofar as a shunt voltage feed is provided for the plate of the rectifier 5. It will be observed that in this arrangement a coupling condenser 11 is utilized to couple the high alternating voltage side of the tunable local oscillator circuit to the plate circuit of tube 5. The signal energy for the rectifier tube is impressed upon its signal grid from the tuned circuit 6 through a coupling condenser 12, and a grid leak resistor 13 is connected between the grid side of condenser 12 and the negative terminal of the voltage source C. It will be observed that connections not necessary to an understanding of the arrangement are omitted in order to preserve simplicity of disclosure. The condenser 11 is charged up by the plate currents.

Sufficient voltage from the local oscillator circuit may be obtained in a superheterodyne receiver, and by proper design there should be no difficulty in obtaining a peak oscillator voltage of 40 to 60 volts. Those skilled in the art will readily be able to design the local oscillator circuit so as to provide a proper operating voltage for the plate of rectifier tube 5.

In Fig. 3 there is shown still another arrangement for utilizing the local oscillator voltage of a superheterodyne receiver as the operating voltage for the plate of the automatic volume control tube. In this arrangement a small diode, or other rectifier, is added so that the bias on the controlled amplifier tubes can be made twice as high as the peak oscillator voltage. The circuit shown is similar to that usually employed for voltage doubling, except that the automatic volume control tube is used in place of one of the diodes, and the connection is similar. The signal strength determines the amount of drop appearing across the automatic volume control resistor R, which furnishes the bias for the grids of the controlled amplifier tubes. The pentode rectifier 5' has its signal grid connected to the cathode of diode tube 14 through a resistor 15, resistor 15 being connected between the cathode and anode of diode 14.

The anode side of resistor 16 is connected to the negative terminal of the voltage source C, and a signal coupling condenser 17 connects the cathode side of resistor 16 to the signal network feeding the second detector. The voltage doubling diode 18 has its cathode connected to the plate of tube 5', which the anode of diode 18 is connected to the cathode of tube 5' through the bias voltage resistor R, a by-pass condenser 19 being connected across the resistor R. The cathode and anode of diode 18 are, additionally, connected by a path which includes the coil 7' and the condenser 20. The tunable local oscillator circuit 9—10 is magnetically coupled to the coil 7', and the condenser 20 is charged by the diode anode to have the polarity shown. The function of diode 14 is to change the signal

voltage to a steady direct current voltage for controlling the grid of tube 5'. Audio and radio frequency voltages are filtered from the input to this grid by resistor 15 and the condenser 15'. In this way the AVC is rendered independent of the modulation.

In Fig. 4 there is shown an interchannel noise suppressor circuit embodying the present invention. In the arrangement shown in Fig. 4 the automatic volume control circuit may be of any well known and conventional type. For this reason the lead designated AVC, and which lead emanates from the second detector network, is to be understood as representing any desired form of volume control circuit which may be used to control the gain of the radio frequency and intermediate frequency amplifier stages. In fact, any of the automatic volume control arrangements shown herein may be utilized for that purpose. Fig. 4 is particularly directed to disclosing the manner of utilizing the local oscillator energy for operating an interchannel noise suppressor, or a muting, network. As is well known to those skilled in the art, such a network is utilized to quiet, or silence, the operation of the receiver between station positions of the tuning means of the receiver, or, in general, whenever the signal input to the receiver falls below a predetermined signal threshold value.

In particular, the noise suppressor operates by controlling the action of the audio frequency amplifier tube 21. The noise suppressor tube is shown as of the type comprising a pentode section and a diode section, and is designated by the reference numeral 22. Signal energy is impressed upon tube 22 by means of the transformer M₃ having its primary and secondary windings tuned to the operating intermediate frequency, the primary winding being coupled to the intermediate frequency network feeding the audio demodulator, or second detector. The tuned secondary circuit of transformer M₃ is connected between the cathode of tube 22 and the diode anode 23 through a resistor 24, the latter being shunted by a radio frequency bypass condenser. The signal grid of the pentode section of tube 22 is connected to the anode side of resistor 24 through a resistor 25, a by-pass condenser being connected between the cathode and the grid side of resistor 25.

The negative terminal of the battery source C is connected to the plate of the pentode section of tube 22 through a path which includes the coil 26, resistor 27, the latter being shunted by condenser 28. The cathode of tube 22 is connected by lead 29 to the cathode of the audio amplifier 21. The signal grid of tube 21 is connected to the plate side of resistor 27 through a path which includes resistor 30 and resistor 31, a condenser 32 being connected between the cathode of tube 21 and the low alternating voltage side of resistor 30. The tunable local oscillator circuit is again represented by the numerals 9 and 10, and the coil 26 is magnetically coupled to the coil 9 of the oscillator circuit. The arrangement shown in Fig. 4 shows a series feed for the plate voltage of the noise suppressor tube 22, and also a series feed for the diode of this tube.

In Fig. 5 there is shown a similar arrangement which differs from Fig. 4 only in that a shunt feed is provided for the plate voltage of the noise suppressor tube, and a shunt feed is also provided for the diode section of the tube. In Fig. 5 the high alternating voltage side of the

local oscillator circuit 9—10 is connected by coupling condenser 33 to the plate of the suppressor tube, the network connected to the diode section of the suppressor tube being slightly modified in the manner shown.

One of the two resistors 22', connected between the diode anode and cathode, serves to let the charge on the coupling condenser leak off when the signal voltage is removed. The other resistor 24 and the condenser, between grid and cathode, serve as a filter to remove audio and radio frequency voltages from the input to the grid of the tube. In this way the control is rendered independent of the variation in the carrier envelope caused by the modulation.

The arrangements shown in Figs. 4 and 5 operate in the same manner, and function to maintain the output of the receiver quiet until a signal carrier of at least a predetermined strength is tuned in. It will be noted that in each case the common A, B and C batteries are used for all tubes. In each case the alternating current for the operation of the plate of the suppressor tube is secured from the local oscillator tube. This alternating current on the plate is the same as if a separate battery were used by permitting the load resistor to be connected to at the cathode, or to a point more negative than the cathode. In operation, and without any signal present, current is flowing in the plate circuit of the noise suppressor tube. The voltage drop in resistor 27 will bias off the audio tube to render it inoperative. As soon as a strong signal is tuned in the diode section of tube 22 will bias off the grid of the pentode section of tube 22, and cut down the plate current flow through resistor 27. Thus, the voltage drop across resistor 27 will be greatly reduced, and approach zero as a limit, and the audio tube will then be permitted to function normally.

Instead of employing a diode section in connection with the noise suppressor tube, the ordinary grid leak detector operation of the control grid of the pentode section of the tube may be used. Again, a portion of the voltage drop across resistor 27 may be used to partially bias off an intermediate frequency amplifier tube feeding the noise suppressor tube. The action will then possess more of an "off-on" characteristic, and be less gradual.

While I have indicated and described several systems 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 organizations 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 an automatic gain control system for a superheterodyne receiver, an amplifier whose gain is to be controlled, a rectifier, the rectifier including a tube provided with a plurality of electrodes, certain of said electrodes comprising input electrodes, means for impressing signals upon the input electrodes, and means for impressing local oscillations generated in the receiver upon an output electrode of said rectifier tube, a resistor in the space current path of said rectifier tube across which is developed a direct current voltage derived from the rectifier space current in response to a predetermined change in signal amplitude, and a gain control connection connected between a negative point on the re-

sistor and a gain control electrode of the amplifier.

2. In a receiver of the automatic volume control type, a demodulator, an audio amplifier, a background noise suppressor tube, said tube including an amplifier section and a diode section, means for impressing signals upon the diode section, said diode section providing a rectifier circuit, means responsive to variations of current in the diode rectifier circuit for varying the space current flow in said amplifier section, a gain control connection between the said amplifier section and said audio amplifier tube, and means for impressing oscillations generated in the receiving system upon the output electrodes of said amplifier section.

3. In a system as defined in claim 1, means for establishing a negative bias on one of the input electrodes of said rectifier tube.

4. In a receiver as defined in claim 2, said impressing means being capacitatively coupled to said output electrodes.

5. In combination in a superheterodyne receiver of the type including a local oscillator network and at least one signal amplifier tube, a rectifier tube network having a uni-directional space current path established between at least two electrodes thereof, an impedance in said path for developing a gain control voltage from the space current flow therethrough, means for impressing oscillations from said oscillator network between said two electrodes for rectification of said oscillations, means responsive to variations in signal carrier amplitude for regulating the space current flow of said path, said last means comprising a pair of signal input electrodes disposed within said rectifier tube, and means for applying said control voltage to at least one gain control electrode of the amplifier.

6. In combination in a superheterodyne receiver of the type including a local oscillator network and at least one signal amplifier tube, a rectifier tube network having a uni-directional space current path established between at least two electrodes thereof, an impedance in said path for developing a gain control voltage from the space current flow therethrough, means for impressing oscillations from said oscillator network between said two electrodes for rectification of said oscillations, means including a signal rectifier responsive to variations in signal carrier amplitude for regulating the space current flow of said path, said last rectifier having its electrodes disposed within the said rectifier tube, and means for applying said control voltage to at least one gain control electrode of the amplifier.

7. In combination in a superheterodyne receiver of the type including a local oscillator network and at least one audio signal amplifier tube, a rectifier tube network having a uni-directional space current path established between at least two electrodes thereof, an impedance in said path for developing a gain control voltage from the space current flow therethrough, means for impressing oscillations from said oscillator network between said two electrodes for rectification of said oscillations, means responsive to variations in signal carrier amplitude for regulating the space current flow of said path, and means for applying said control voltage to at least one gain control electrode of the amplifier in a sense to render the amplifier inoperative when the signal carrier amplitude decreases below a desired intensity level.

8. In a superheterodyne receiver of the type

including a local oscillator network, a demodulator, and at least one signal transmission tube coupled to the demodulator, means responsive to signal carrier amplitude variations at the receiver input for maintaining the amplitude substantially uniform at the demodulator input circuit, noise suppression means comprising an electron discharge device having an impedance connected in its space current path, means for impressing oscillations from said oscillator network upon two electrodes of the rectifier between which said current flows, direct current connections between said impedance and the input electrodes of said transmission tube for rendering the latter inefficient with the voltage developed across the impedance by the rectifier space current in the absence of desired signals, and auxiliary means, responsive to received signals, for reducing the rectifier space current flow through the impedance.

9. In a superheterodyne receiver of the type including a local oscillator network, a demodulator, and at least one signal transmission tube coupled to the demodulator, means responsive to signal carrier amplitude variations at the receiver input for maintaining the amplitude substantially uniform at the demodulator input circuit, noise suppression means comprising an electron discharge device having an impedance connected in its space current path, means for impressing oscillations from said oscillator network upon two electrodes of the rectifier between which said current flows, direct current connections between said impedance and the input electrodes of said transmission tube for rendering the latter inefficient with the voltage developed across the impedance by the rectifier space current in the absence of desired signals, and auxiliary means including a control electrode disposed in said path, responsive to received signals, for reducing the rectifier space current flow through the impedance.

10. In a superheterodyne receiver of the type including a local oscillator network, a demodulator, and at least one signal transmission tube coupled to the demodulator, means responsive to signal carrier amplitude variations at the receiver input for maintaining the amplitude substantially uniform at the demodulator input circuit, noise suppression means comprising an electron discharge device having an impedance connected in its space current path, means for impressing oscillations from said oscillator network upon two electrodes of the rectifier between which said current flows, direct current connections between said impedance and the input electrodes of said transmission tube for rendering the latter inefficient with the voltage developed across the impedance by the rectifier space current in the absence of desired signals, and auxiliary means, responsive to received signals, for reducing the rectifier space current flow through the impedance, said auxiliary means comprising a diode rectifier coupled to the demodulator input circuit, and a direct current control connection from the diode to a control electrode disposed in said first rectifier space current path.

11. In a superheterodyne receiver of the type including a local oscillator network, a demodulator, and at least one signal transmission tube coupled to the demodulator, means responsive to signal carrier amplitude variations at the receiver input for maintaining the amplitude substantially uniform at the demodulator input circuit, noise suppression means comprising an elec-

tron discharge device having an impedance connected in its space current path, means for impressing oscillations from said oscillator network upon two electrodes of the rectifier between
5 which said current flows, direct current connections between said impedance and the input electrodes of said transmission tube for rendering the latter inefficient with the voltage developed across the impedance by the rectifier space current in the absence of desired signals, and auxiliary means, responsive to received signals, for
10 reducing the rectifier space current flow through the impedance, said transmission tube following said demodulator and receiving therefrom the audio component of demodulated signals, and the
15 auxiliary means including a rectifier coupled to the demodulator input circuit to have intermediate frequency energy impressed thereon.

12. In combination in a superheterodyne receiver of the type including a local oscillator net-

work and at least one signal amplifier tube, a rectifier tube network having a uni-directional space current path established between at least two electrodes thereof, an impedance in said path
5 for developing a gain control voltage from the space current flow therethrough, means for impressing oscillations from said oscillator network between said two electrodes for rectification of said oscillations, means responsive to variations
10 in signal carrier amplitude for regulating the space current flow of said path, and means for applying said control voltage to at least one gain control electrode of the amplifier, said second
15 means comprising a signal rectifier whose electrodes are disposed in said rectifier tube, and a control electrode disposed in said space current path and having a direct current connection to an electrode of said second rectifier.

WINFIELD R. KOCH. 20