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AUTOMATIC VOLUME CONTROL WITH NOISE SUPPRESSION

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Fig. 1

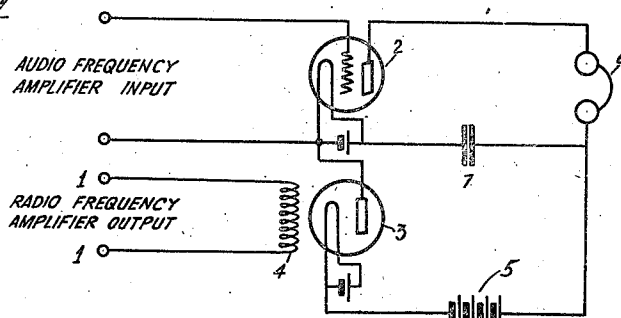


Fig. 2

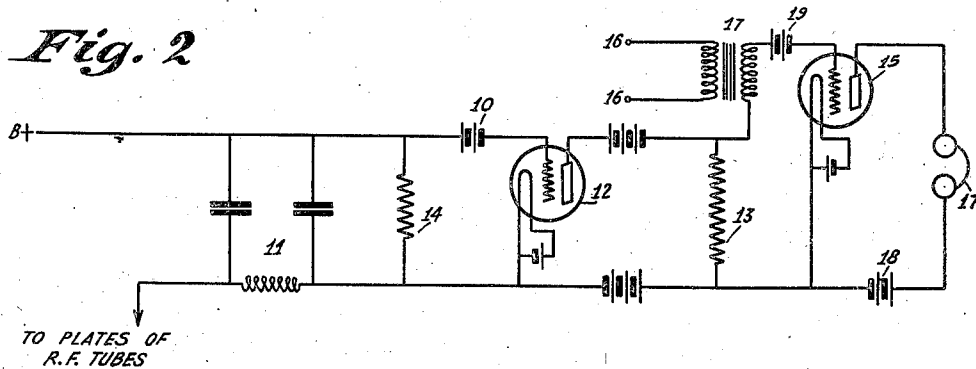


Fig. 3

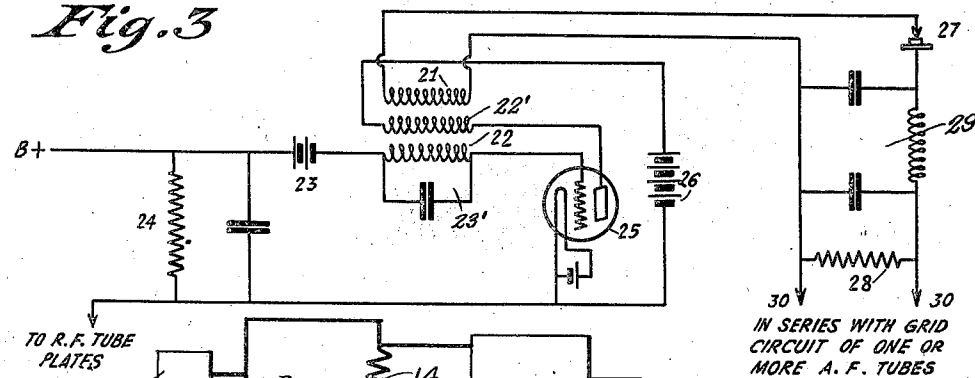
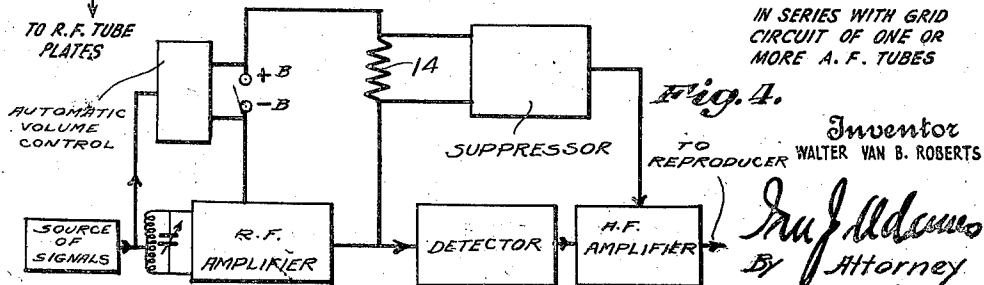


Fig. 4.



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AUTOMATIC VOLUME CONTROL WITH
NOISE SUPPRESSIONWalter van B. Roberts, Princeton, N. J., as-
signor to Radio Corporation of America, a
corporation of DelawareApplication December 19, 1928, Serial No. 326,990
Renewed September 18, 1931

29 Claims. (Cl. 250—20)

It is well known that in radio receivers having automatic volume control an annoying hiss occurs when, in tuning, the dial passes over frequency bands containing no signal energy. This is due undoubtedly, to the fact that in such devices, amplification automatically becomes very great in the absence of signals with the result that static and other noises are amplified to a great degree.

This, of course, is inherent due to the very nature and way that the said volume controls operate, that is, the less energy coming into the receiver, the greater the tendency to amplify.

In some automatic volume control arrangements, such, for example, as disclosed in patent of T. A. Smith, entitled "An Automatic gain control", Patent No. 1,999,668, issued April 30, 1935, the plate current supplied to the tubes in the radio frequency amplifying system varies in accordance with the amplification. For instance, in certain particular devices of this type the current supply to the radio frequency tube is about 15 mils when very weak signals are received, somewhat more than 15 mils when no signals are present, and less than 15 mils when loud signals are present; that is, approximately inversely proportional to the strength of the signal. This, of course, is true only within certain limits.

The broad system of noise suppression in automatic gain control systems is disclosed and claimed in an application filed by Arthur F. Van Dyck et al., Serial No. 465,852, filed July 7, 1930.

The purpose of the present invention is to construct a device for eliminating the above undesired effects without in any way impairing the operativeness and effectiveness of the volume control device.

Another purpose of the invention is to utilize a vacuum tube in its various capacities for accomplishing the desired results.

Still other purposes will appear in the descriptive matter which is to follow when read in connection with the drawing in which:

Figure 1 illustrates diagrammatically one embodiment of my invention in which a vacuum tube of the type known as a "magnetron" is used for the control resistance,

Figure 2 illustrates diagrammatically a mode of accomplishing the objects of my invention by the use of a triode tube and suitable biasing means;

Figure 3 diagrammatically illustrates another embodiment of my invention in which an oscillation circuit is made use of for the control means.

In Fig. 4 is shown schematically a complete radio receiver embodying the present invention, as applied specifically to Fig. 2.

In the following matter which is given solely for purposes of clearly describing the invention and not for purposes of limitation, specific examples will be given in order that a clearer understanding of the invention will be possible; however, in no case is it to be taken that the particular values chosen or given by way of illustration are intended as a curtailment on the scope of the invention, except as set forth in the claims.

In Figure 1, device 3 represents diagrammatically a magnetron tube of well known type having an anode surrounding an electron emitting filament within an enclosure and 4 represents its external control coil. This tube is so constructed that it presents a relatively low direct current internal resistance when the current in its control coil 4 is less than a certain amount and a much greater internal resistance when the current in the said control coil exceeds a certain amount; that is, the device is constructed so as to be very sensitive to changes in current passing through the control coil. The coil 4, through leads 1—1, is connected in the plate current circuit of the radio frequency amplifier of the receiving apparatus, not shown. Tube 2 represents the audio output tube of the radio receiving apparatus and as is evident from the drawing the plate supply 5 of the audio tube is in series with the magnetron tube 3 so that the magnetron tube acts as a current limiting relay or control valve for the plate supply of tube 2. A loudspeaker or indicator 6 and a by-pass condenser 7 are connected in the output circuit in the manner shown.

It is thus seen that as the magnetron tube 3 is in series with the plate supply 5 of the audio amplifier output tube 2 it very substantially decreases the plate current of the audio output when the current in winding 4 exceeds a certain amount, say in this case 15 mils, and that it allows normal current to flow to the plate of tube 2 when the current through 4 is less than 15 mils and that by suitable adjustments the current limiting control may be made quite critical. The current in winding 4 being in the plate current supply of the radio frequency tubes has its value determined by the automatic volume control.

The operation of the device in Figure 1 is as follows: When no signal is present the volume control tends to increase the amplification which results in great amplification of static and other undesired noises thus causing more current to go through coil 4 which in turn controls tube 3 in

such a way that the audio frequency end of the circuit is made substantially inoperative whereby the undesired noises will not be heard through the phones 6.

5 If desired, a supplementary biasing direct current through 4 may be supplied to make the magnetron cut off at the desired field strength, or a separate control coil may be preferably provided for the biasing current.

10 In Figure 2, 12 is a triode having biasing means such as a grid battery 10. The plate current of the volume controlled radio frequency tubes (not shown) goes from B+ through resistance 14 to the plates as shown by the arrow. Resistance 14
15 is arranged so as to be in the input circuit of the triode 12 so that changes in potential drop across the ends of the resistance 14 due to an increase in the plate current of the radio frequency tubes will affect the bias upon the grid of tube 12.
20 Battery 10 is of such voltage that it just shuts off plate current through resistance 13 when the radio frequency plate current flowing through resistance 14 has the assumed critical value of 15 mils. Tube 15 is the last audio stage of the
25 receiver, and terminals 16—16 are the input terminals to the audio transformer 17. A suitable grid bias source, such as battery 19, a plate current supply 18 and a telephone receiver device 17 are connected to the tube 15 as shown.

30 In this modification it is seen therefore that a normal flow of current (15 mils or less) through 14 will cause no change whatever in the receiver. However, suppose that due to the absence of signals the automatic volume control functions
35 in such a way that a current say in excess of 15 mils flows through 14. The potential drop thus produced across resistance 14 opposes the grid biasing battery 10 potential and causes the grid to become sufficiently less negative to permit some current to flow through resistance 13.
40 This in turn causes more bias on the grid of audio tube 15 which, may be any one or all audio tubes of the circuit, (only one being shown here for convenience). Due to the amplifying action
45 of the tube 12, an increase in the radio frequency plate current to 16 mils, for example, can readily be caused to increase the negative bias of tube 15 sufficiently to cut off all the plate current. A decrease, say to 14 mils however,
50 would make no difference as there is no current at all through 13 except when the radio frequency plate current is greater than 15 mils.

In the modification shown by Figure 3, 25 is a triode having its input and output coupled in any well known manner, for example by the coupling 22, to produce oscillations under certain conditions. The plate current for the radio frequency tubes (not shown) goes through from
60 B+, resistance 24 to the plate electrodes of the radio frequency tubes in substantially the same manner as shown in Figure 2. Coil 21, coupled to control grid coil 22 through the anode coil 22', rectifier 27, resistance 28 and filter 29 constitute
65 a rectifier circuit having its input coupled to the oscillatory circuit 23' of tube 25. The rectifier is shown diagrammatically as a crystal 27 although any type of rectifier may be employed. The current smoothing circuit or filter unit 29
70 is included so that a smooth direct current is derived from the rectifier. Resistance 28 is supplied in the rectifier circuit in series with the grid circuit 30—30 of one or more of the audio frequency tubes of the circuit. A source of plate

voltage 26 is included in the plate circuit of tube 25.

It is evident from the figure that when the radio frequency amplifier plate current becomes excessive, say above 15 mils, more current will
5 flow through resistance 24 thereby increasing the potential drop, or voltage, across said resistance making the grid of tube 25 become less negative due to the fact that the potential across the resistance 24 overcomes the effect of battery
10 23 when the current through 24 reaches a certain value. When the effect of battery 23 is overcome, strong oscillations will be initiated in tube 25. These oscillations are picked up by
15 coil 21, rectified by rectifier 27 and smoothed out by the filter 29. The resulting direct current is passed through the resistance 28 thus giving a biasing voltage which is applied in series with the grids of one or more of the audio frequency tubes which in turn will shut off the output, as
20 in the case of Figure 2.

When this current is properly proportioned with respect to the different biases the audio frequency plate supply will be entirely, or substantially cut off, with the result that the undesired noises are precluded from being sent
25 through the telephones, or other sound reproducing devices.

In the three modifications shown, the audio output should be shut off, or greatly diminished,
30 only when the plate current of the radio frequency tubes increases above a certain predetermined amount (say 15 mils) in average value averaged over a reasonable time.

To insure this, in any of the modifications, a low pass filter may be inserted in the connection between the radio frequency plate circuit and the means for shutting off the audio frequency tube output, as shown by way of illustration at Figure 2, by network 11 which device
40 will allow any temporary rise in current resulting from an unusually great amplitude modulation, as for instance, in the case of a loud note in broadcasting a musical selection, to be by-passed.
45

Fig. 4 is a schematic diagram of a complete receiver embodying the invention, and it is to be clearly understood that the diagram is purely conventional, or functional, in nature. The input of the radio frequency amplifier includes
50 a tuner, and the latter is symbolized by the usual variable condenser representation. The detector is fed with the amplified radio frequency energy; it detects the energy, and transmits the detected energy to an audio frequency amplifier.
55

The block designated "Automatic volume control" symbolizes the arrangement for automatically regulating the gain of the radio amplifier. As stated above, its specific form may follow the teachings of the aforesaid Smith patent. The
60 audio frequency amplifier control, or background noise suppressor, is functionally shown as being fed by a portion of the radio amplifier output; the output of the suppressor being employed to control the amplification efficiency of the audio
65 amplifier. The schematic representation of the background noise suppressor generally illustrates the functions of each of the modifications in Figs. 1, 2, 3. The resistor 14 is the resistor shown in the grid circuit of tube 12 of Fig. 2. As shown
70 in the aforesaid Smith patent, the automatic volume control functions to vary the flow of radio frequency amplifier plate current through resistor 14. The latter is to be replaced by coil 4, or resistor 24, when the system is used in con-
75

nection with the arrangements of Figs. 1 and 3 respectively.

In each case, whenever the receiver tuner is adjusted to a point in the tuning adjustment range where signal energy below a predetermined intensity level is collected, the background noise suppressor automatically functions to render the audio amplifier inefficient to transmit energy to the reproducer. This of course, prevents the reproduction of undesired background noise impulses, which impulses tend to be greatly amplified by the radio amplifier whenever the collected signal energy decreases in intensity below the aforesaid minimum level.

Having thus described my invention what I desire to protect by Letters Patent is as follows:

1. In a radio receiving circuit having an automatic volume control device, an intermediate space discharge device circuit having its input coupled to the output of one of the radio frequency amplifier stages of said receiving circuit, and its output coupled to the input of an audio frequency amplifier stage thereof, means in said intermediate space discharge device circuit for normally maintaining said device in an inoperative state, means for overcoming said first named means upon an abnormal increase in output current in said radio frequency amplifier whereby said device is rendered operative and means controlled thereby for limiting the amplifying characteristics of said audio frequency amplifier stage.

2. In radio receiving apparatus having automatic volume control means, an electron discharge device having an input circuit and an output circuit, said input circuit forming a portion of the radio frequency amplifier output of said receiving apparatus and said output circuit forming a part of the audio frequency input circuit of said device and means in said input circuit for overcoming said biasing potential when the current in said radio frequency amplifier output exceeds a certain predetermined value only when sustained over an appreciable length of time.

3. In a radio receiving circuit having a radio frequency amplifier an audio frequency amplifier, and an automatic volume control device, a tube circuit having its input resistively coupled to the plate supply of said radio frequency amplifier through a low pass filter and its output resistively coupled to the input circuit of said audio frequency amplifier and a biasing device in said tube input circuit for normally maintaining said tube inoperative.

4. In a multi-stage receiving circuit having an automatic volume control device, auxiliary means for coupling any stage thereof to any succeeding other of said stages comprising a normally inoperative space discharge device circuit having an input circuit comprising a biasing means and a resistance in series, and an output circuit comprising a resistance and a plate current supply, said resistances being utilized for coupling said space discharge device circuit between said other stages respectively and means whereby when a current exceeding a predetermined value flows through said first mentioned resistance for a sustained predetermined time interval said space discharge device will be rendered operative whereby a current will flow through said second resistance and means controlled thereby for controlling the output of the stage connected thereto.

5. A signalling system comprising a high frequency amplifier circuit, means for tuning said

circuit through a range of frequencies, a gain control device for regulating the sensitivity of said amplifier, electron discharge tube means for utilizing the amplifier output and additional means comprising an electron discharge device for automatically decreasing the utilizing efficiency of said last means when said amplifier is adjusted to maximum sensitivity but is tuned through a point of said range where less than a predetermined amount of high frequency energy is received.

6. A signalling system comprising a high frequency amplifier circuit, means for tuning said circuit through a range of frequencies, a gain control device for regulating the sensitivity of said amplifier, means for changing the frequencies amplified at high frequency to a low frequency, a low frequency amplifier and additional means including a space discharge relay for automatically impairing the transmission efficiency of the low frequency amplifier when the high frequency amplifier is adjusted to maximum sensitivity but is tuned through a point of the range where no high frequency energy is received.

7. A receiving system comprising a signal translating tube device, a radio frequency amplifier coupled to said device, means for regulating the sensitivity of said amplifier inversely with received signal energy level and means comprising an electron discharge relay for disabling said tube device when said amplifier is adjusted to maximum sensitivity by said regulating means and no signal energy is received.

8. In combination, a radio receiver comprising, a radio frequency amplifier and a low frequency amplifier, means for controlling the amplification factor of the radio frequency amplifier and an electron discharge relay arranged to be actuated by variations in the output of said radio frequency amplifier for reducing the transmission efficiency of the low frequency amplifier when the gain of the radio frequency amplifier is adjusted to a maximum and no carrier wave is received.

9. In combination, a radio receiver comprising, a radio frequency amplifier, a frequency changing means and a low frequency amplifier, means for controlling the gain of the radio frequency amplifier and an electron discharge device arranged to be actuated by variations in the output of said radio frequency amplifier for reducing the transmission efficiency of the low frequency amplifier when the gain of the radio frequency amplifier is adjusted to a maximum and no carrier wave is received, said electron discharge device being connected between the radio frequency amplifier and the said low frequency amplifier.

10. In a signalling system which includes an amplifying circuit and a gain control device for regulating the sensitivity of the amplifier with tube means for utilizing the amplifier output, in combination, an electron discharge device, responsive to a predetermined energy variation in the amplifying circuit output, for automatically decreasing the utilizing efficiency of the last tube means when said amplifier is adjusted to maximum sensitivity and where less than a predetermined amount of energy to be amplified is available.

11. In a signalling system which comprises a high frequency amplifier adapted to be tuned through a range of frequencies, a gain control device for regulating the sensitivity of said amplifier, means for changing the frequencies amplified at high frequency to a low frequency, a low frequency amplifier, in combination a space

discharge relay, responsive to a predetermined energy variation in the high frequency amplifier output, for automatically impairing the transmission efficiency of the low frequency amplifier when the high frequency amplifier is adjusted to maximum sensitivity but is tuned through a point of the range where the intensity of the incoming high frequency energy is below a predetermined value.

12. In combination with a radio receiver including a high frequency amplifier, a detector, a lower frequency amplifier, and an arrangement for automatically regulating the gain of said high frequency amplifier, a device for automatically suppressing the reproduction of undesired background noise impulses when the sensitivity of said high frequency amplifier is increased above a predetermined level by said regulating arrangement, said device comprising a circuit connected to said low frequency amplifier, said circuit including means, responsive to said increased sensitivity, for controlling the bias of an input electrode of said low frequency amplifier.

13. In a radio receiver, in combination, an audio frequency amplifier, a detector connected to the input of the amplifier, a high frequency network connected to the detector input, an automatic volume control circuit for regulating the transmission efficiency of said network in such a manner that the radio frequency input to the detector is substantially constant regardless of signal carrier intensity fluctuations in the input of said network, and means responsive to variations in the magnitude of the received signal energy for adjusting the bias of an input electrode of said audio amplifier in a sense such that the audio amplifier output is greatly diminished when the signal energy magnitude decreases below a predetermined intensity level.

14. In a radio receiver, in combination, a radio frequency amplifier, means for automatically adjusting the gain of said amplifier, said receiver additionally including a rectifier and a low frequency amplifier in a network following said radio amplifier, and an auxiliary means, operative upon adjustment of said radio amplifier to maximum sensitivity and when signal energy below a minimum intensity level is impressed on said radio amplifier, for automatically biasing a control electrode of said network to cut-off.

15. A radio signalling system of the type including a resonant high frequency transmission network, tuned to a desired frequency, a demodulator and an audio amplifier, means for automatically regulating the transmission efficiency of said network in such a manner that the signal energy input to the demodulator is at a substantially constant level, and additional means, responsive to a decrease of the said signal input below a minimum level, for automatically biasing the audio amplifier in a sense such that the transmission efficiency of the latter is substantially impaired.

16. In combination with an audio frequency amplifier having a control electrode and a source of audio signal frequency energy therefor, a space discharge device having at least one electrode electrically connected with said source in such a manner that a decrease in intensity of said energy below a minimum level results in a predetermined variation in direct current potential of said electrode, and an additional electrode in said device connected to a transmission control electrode of said amplifier, and responsive

to said potential variation, for impairing the transmission efficiency of said amplifier when said energy decreases below said level.

17. In combination with the audio frequency amplifier of a radio receiver, a background noise suppressor tube having its input electrodes connected to a point in said receiver preceding the input of said amplifier, the output electrodes of the tube being connected to the input circuit of said amplifier, means in the said input circuit for establishing a normal potential difference between the amplifier input electrodes such that the amplifier is efficient when audio signal energy is impressed thereon, additional means, connected to the output electrodes of said tube, for providing a potential difference between said amplifier input electrodes adapted to bias the amplifier to cut off, and means connected to the suppressor tube input electrodes for normally biasing the suppressor tube to inoperative state as long as said signal energy is impressed on said amplifier.

18. In a radio broadcast receiver provided with a plurality of electron discharge tubes included in successive stages of the receiver, means for tuning the receiver through the broadcast tuning range, automatic volume control means for maintaining the audio output level of the receiver substantially uniform regardless of signal carrier fluctuations, an auxiliary control arrangement adapted to operate when said tuning means is adjusted to a setting at which broadcast signal energy below a minimum intensity level is collected, said control arrangement including a biasing means, responsive to increased receiver sensitivity below said minimum level, for biasing at least one of said tubes to cut-off.

19. A method of radio frequency signal reception which includes the steps of collecting signal energy, amplifying the amplitude of the collected energy, regulating the amplification of said collected energy with a portion of the amplified energy in a direction to oppose variations in the intensity level of the carrier of the collected signal energy, detecting the amplified energy, amplifying the detected energy, and regulating the amplification of the detected energy with a portion of the said amplified collected energy in a direction opposite to that of said first regulation when the said level decreases below a desired minimum value.

20. A method of radio frequency signal reception which includes the steps of collecting signal energy, amplifying the amplitude of the collected energy, regulating the amplification of said collected energy with a portion of the amplified energy in a direction to oppose variations in the intensity level of the carrier of the collected energy, rectifying the amplifier energy, amplifying the rectified energy, and regulating the amplification of the rectified energy with a portion of the said amplified collected energy in a direction opposite to that of said first regulation when the said level decreases below a desired minimum value.

21. In a multi-stage radio receiver having an automatic volume control device, an auxiliary coupling circuit comprising an electron discharge device having its input coupled to the output of one of the stages of the radio frequency amplifier and its output coupled to the input of one of the stages of the audio frequency amplifier of said receiver and means upon the attainment of a predetermined condition in the output

of said radio frequency stage for rendering said audio frequency stage inoperative.

22. In a radio receiving circuit, an auxiliary space discharge device circuit having its input coupled to the radio frequency amplifier output and its output coupled to the audio frequency amplifier input of said radio receiving circuit, said audio input being also coupled to said radio frequency output, means in said radio frequency output for affecting the conductivity of said auxiliary space discharge device and means controlled thereby for controlling the output of said audio frequency amplifier.

23. In a radio receiver, automatic volume control means acting automatically to decrease the sensitivity of the receiver with increase in signal energy, a uni-lateral current device in the signal path of said receiver having at least two electrodes, and means controlled in operation by the automatic volume control means for biasing the electrodes of said uni-lateral device in a direction to decrease the sensitivity of the receiver when the signal energy is below a predetermined intensity level.

24. In a radio receiver, a uni-lateral current device in the signal path thereof having at least two electrodes, means for biasing the electrodes relative to each other in a direction, and to an extent, such as to prevent the production of undesired noises by the receiver, and means responsive automatically to received signal energy for varying said bias in a direction to increase the sensitivity of the receiver to the received signals.

25. In a radio receiver, automatic volume control means, a uni-lateral device in the signal path of the receiver having at least two electrodes, means for biasing the electrodes relative to each other, and means controlled by the automatic volume control means for varying the bias of said uni-lateral device in a direction to lessen the sensitivity of the receiver with decrease in strength of signal energy below a predetermined level.

26. In a radio receiver of the type including a tuned radio frequency amplifier, a detector and an audio frequency utilization network, an automatic amplifier gain control circuit arranged to maintain the carrier amplitude at the detector input substantially constant despite carrier amplitude variations at the amplifier input, a back-

ground noise suppressor network comprising an electron discharge tube independent of any of the signal transmission tubes of the receiver, a resistor operatively associated with said gain control circuit for developing a direct current voltage varying in magnitude with said carrier amplitude variations, said resistor being connected across the input electrodes of said suppressor tube, and connections from the output electrodes of the latter to said utilization network for rendering the transmission of detected signals through the network inefficient when the received carrier amplitude decreases below a predetermined value.

27. In the operation of a high gain wave transmission system, the method of preventing the transmission of currents inadvertently arising within the system which comprises normally biasing said system to suppress transmission therethrough, and automatically removing said suppression bias when the received waves attain a predetermined critical value.

28. In an electrical wave transmission system, the combination with a plurality of radio frequency and audio frequency stages cascaded to form a transmission line, means for controlling the gain of said stages to maintain the signal voltage across predetermined points in said line at a substantially fixed value over a wide range of received signal voltages, and means operative when the received signal voltage drops to a critical value to impress upon an audio frequency stage following said predetermined points a bias voltage which blocks transmission through said following stage.

29. In a radio receiver, a carrier-current amplifier, a non-rectifying modulation-current amplifier responsive to signals from said carrier-current amplifier, means dependent upon the intensity of said carrier current for automatically maintaining the output of said receiver substantially constant over a range of received carrier-current intensities, and means dependent upon the intensity of said carrier-current for rendering said modulation-current amplifier ineffective, thereby reducing the output of said receiver substantially to zero, when the intensity of said carrier-current falls below a predetermined level below said range.

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