

March 16, 1943.

H. M. LEWIS

2,313,952

ATTENUATOR CIRCUIT

Filed April 7, 1938

2 Sheets-Sheet 1

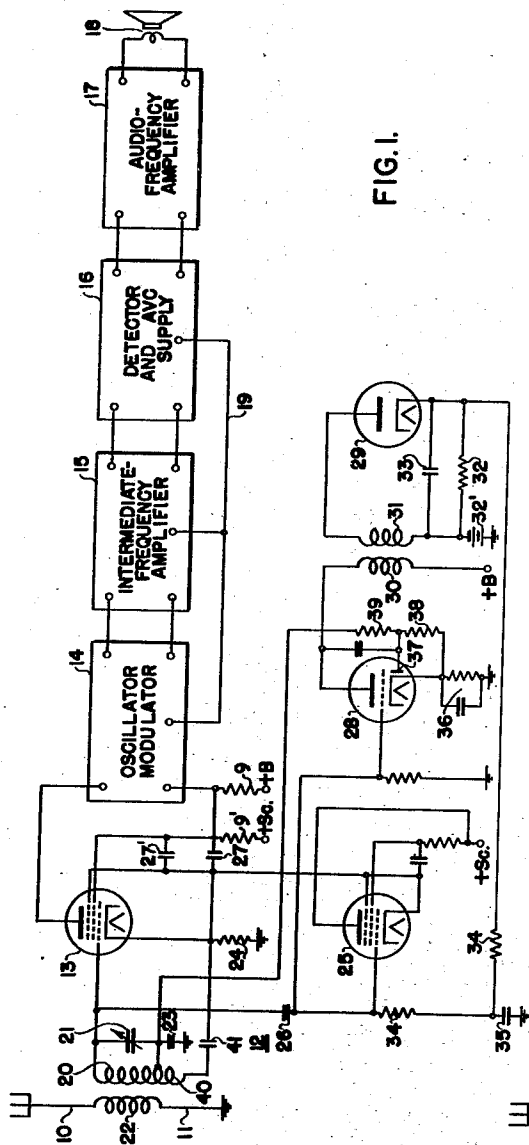


FIG. 1.

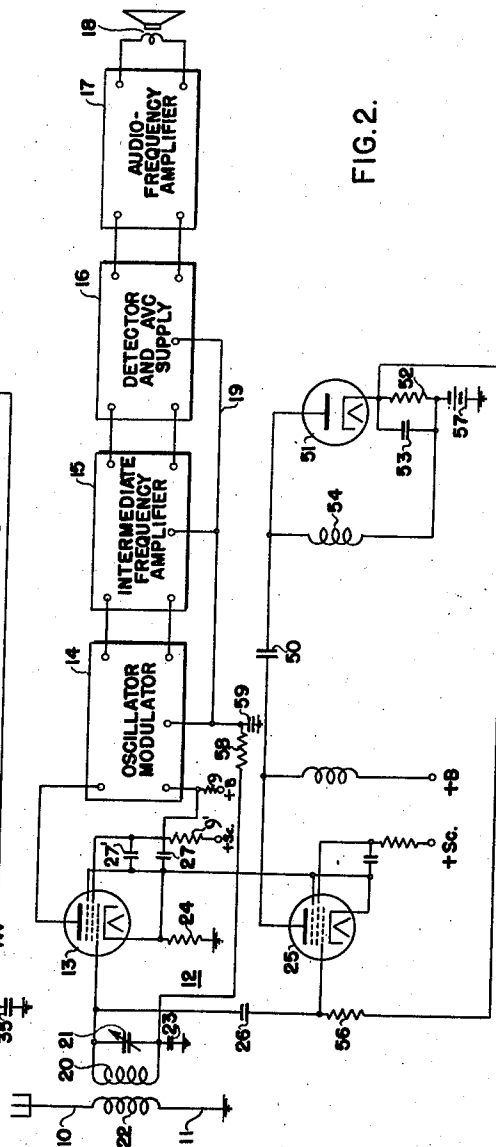


FIG. 2.

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2 Sheets-Sheet 2

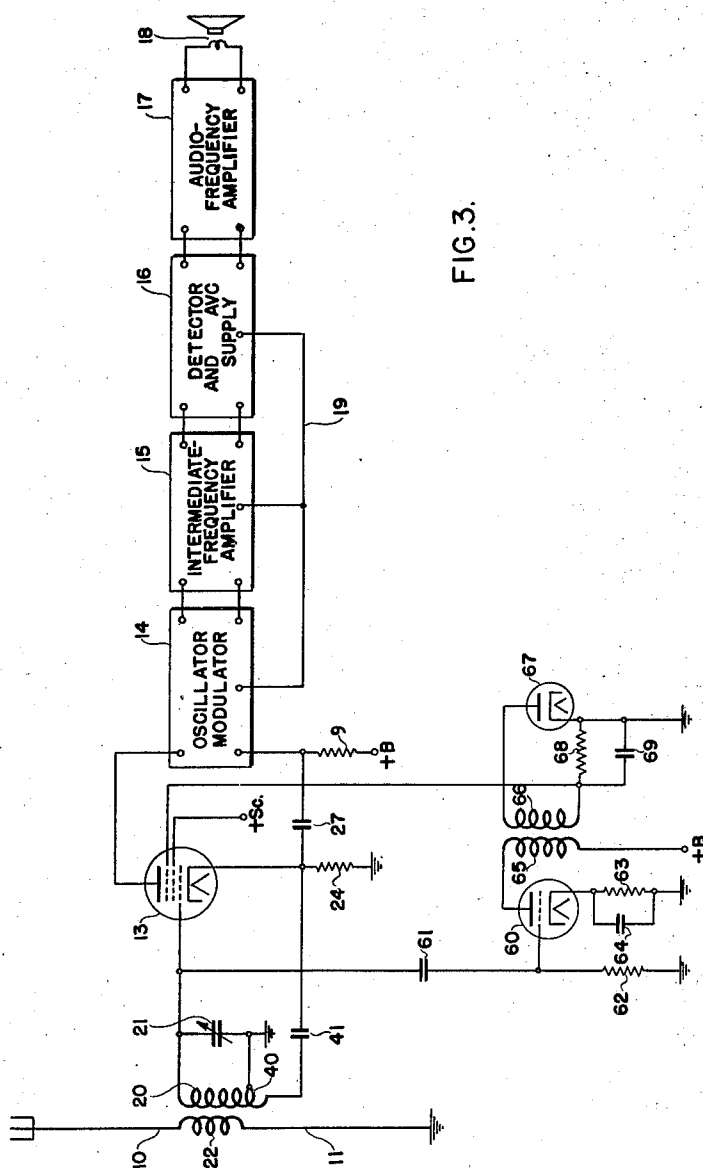


FIG. 3.

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2,313,952

ATTENUATOR CIRCUIT

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Application April 7, 1938, Serial No. 200,647

22 Claims. (Cl. 250—20)

This invention relates to modulated-carrier signal receivers and, more particularly, to an arrangement for reducing the maximum amplitude and the range of amplitude variation of the input to a repeater stage of such a receiver.

Under normal operating conditions, a modulated-carrier signal receiver is subject to the reception of signals of amplitudes varying within very wide limits. As a result, the input to the first repeater stage of the receiver normally has a correspondingly wide range of variation. For weak signals it is desirable to maintain the gain from the antenna to the first repeater stage of the receiver at a maximum in order to raise the signals substantially above the noise level and thus to procure the maximum useful sensitivity of the receiver. However, as the strength of desired received signals increases to such an extent that the swing of the grid of the first repeater stage includes a substantial nonlinear portion of the characteristic curve of the repeater, distortion of the desired signal-modulation envelope and cross modulation of the desired carrier by strong undesired signals may result. This is particularly true in the case of receivers provided with automatic amplification control by which strong signals cause the grid to be biased toward that portion of its characteristic which is most nonlinear. Undesired signals as well as desired signals which reach the input electrodes of the first repeater stage have the effect of increasing the grid swing to such an extent that these disturbing effects result. It is well known that such envelope distortion and cross modulation are effects which cannot be filtered out by succeeding selective circuits.

In general, the preselector circuit (the selector circuit between the antenna and the input circuit of the first vacuum-tube repeater in the signal-translating channel) should be selective to pass a band of desired modulation frequencies sufficiently wide to provide the desired fidelity of reproduction. Generally speaking, if an attempt is made to decrease the total desired and undesired signal input of the first repeater stage by discriminating against the undesired signals passed by the selector, as by adjusting its band width, the fidelity of reproduction is impaired to an undesirable degree. Furthermore, this does not remove the envelope distortion of abnormally strong signals.

Various expedients have heretofore been proposed for automatically and adjustably attenuating the input to the first repeater stage of

a modulated-carrier receiver in order to eliminate the disturbing effects described above. In certain of these arrangements adjustable impedance elements, such as vacuum tubes, have been connected in circuit with the preselector circuit of the receiver adjustably to damp such circuits, thereby adjustably to attenuate the input to the first repeater. This type of element, however, is usually of inherently high impedance which restricts its application to a parallel connection with other elements of the preselector circuit. As thus connected, such an adjustable impedance generally has an undesirable effect on the selectivity or band-pass characteristic of the selector with which it is associated. In addition, both desired and undesired signals may be present with amplitude sufficient to cause nonlinear fluctuations of the vacuum-tube shunt conductance with resulting envelope distortion of the desired signal and cross modulation thereof by an undesired signal in the attenuating tube itself. Furthermore, the interelectrode capacitance of a vacuum tube so connected incidentally influences the resonant frequency of the circuit with which it is connected. This effect is undesirable in radio-frequency preselector circuits which are tunable over a wide range of frequencies, both because it tends to restrict the tuning range and because its detuning effect may vary with adjustments of its attenuation effect.

Another circuit which is not subject to the disadvantages of that just mentioned is described in the copending application of Harold A. Wheeler, Serial No. 149,795, filed June 23, 1937, now United States Patent No. 2,182,329, and assigned to the same assignee as the present invention. The arrangement of the copending Wheeler application, however, utilizes temperature variable resistances in the pre-attenuator circuit, thus adding to the complexity and the expense of the receiver. Still another circuit not subject to the disadvantages mentioned above is described in the copending application of Daniel E. Harnett and John F. Farrington, Serial No. 200,610, filed concurrently with the present application, now United States Patent No. 2,204,216, and also assigned to the same assignee as the present application. Briefly, the arrangement of the Harnett and Farrington application comprises two coupling paths between the antenna and the first vacuum-tube repeater of the signal channel of the receiver. One of these coupling paths is of the conventional type and the other comprises a vacuum-tube signal

repeater, the transconductance of which is varied in accordance with the intensity of received signals. The two coupling paths are oppositely phased so that they develop voltages in phase opposition in the input circuit of the first vacuum-tube repeater of the signal channel of the receiver.

It is an object of the invention, therefore, to provide an improved, simple, and economical attenuator which may be easily adjusted to control the sensitivity of a modulated-carrier signal receiver in such manner as to eliminate the undesired effects described above.

It is a further object of the invention to provide an attenuator for adjustably attenuating the input to the first repeater stage of a modulated-carrier signal receiver with freedom from undesired cross modulation of the desired signal carrier by strong undesired signals on nearby frequencies.

It is a further object of the invention to provide a preattenuator of the type described which secures the desired result without affecting the selectivity of the radio-frequency selector with which it is associated.

Briefly, the above objects are obtained in accordance with one embodiment of the present invention by providing a preattenuator comprising two coupling paths between the antenna and the first vacuum-tube repeater of the signal-translating channel of a modulated-carrier signal receiver, the coupling paths being so arranged as to supply signal voltages of opposite phase to the input circuit of the repeater. One of these coupling paths provides a fixed normal coupling between the antenna and the repeater, while the other path comprises means whereby its transmission efficiency is controlled to vary its effectiveness. When the transmission efficiency of the second coupling path is very small, normal antenna coupling is obtained through the first fixed coupling path. However, when the transmission efficiency of the second coupling path is increased, a substantial voltage approximately in phase opposition to the voltage coupled to the input of the first repeater tube through the normal coupling path is developed in the input circuit of the first repeater through the second or auxiliary coupling path. The output circuit of the second or auxiliary coupling path is connected across a cathode resistor in the input circuit of the first repeater of the signal-translating channel. In one embodiment of the invention, this resistor forms substantially the total load impedance of a signal repeater or control tube included in the second coupling path. As thus connected, the resistor is also effectively a cathode-biasing resistor for both the control tube and the first repeater tube. Variation of the bias voltage applied to the control tube is used to regulate the signal voltage applied to the input circuit of the first repeater through the auxiliary coupling path, thereby reducing the total effective coupling between the antenna and the input circuit of the first repeater stage of the receiver and limiting the resultant voltage applied to the input circuit of the first tube.

In another embodiment of the invention, an attenuator similar in many respects to the embodiment described above is procured by utilizing a single vacuum tube having certain electrodes which are common to the two coupling paths. In this embodiment of the invention, the tube may be of the conventional pentode type, the normal coupling path being connected

to its signal input circuit so that it constitutes the first radio-frequency amplifier of the receiver having an unby-passed cathode resistor, but having its anode circuit returned directly to the cathode for radio-frequency currents. In this embodiment of the invention, the auxiliary or control coupling path, for developing an opposing signal voltage across the cathode resistor of the tube, is provided by the screen-grid circuit of the pentode tube. The transmission efficiency of the tube with respect to the anode and screen-grid circuits is controlled in opposite senses by a potential varying in accordance with the amplitude of received signals which is applied to the suppressor grid.

In accordance with another embodiment of the invention, there is provided in combination with a tube including at least a cathode, a signal input electrode and an output electrode, a signal input circuit which is coupled to the input electrode, and a signal output circuit which is connected to the output electrode. There is also provided a means responsive to electrons diverted from the electron stream flowing between cathode and output electrode for developing a signal voltage. In addition there is provided means for applying the developed signal voltage to the input electrode in degenerative phase relative to the signal voltage from the input circuit, and a single means for simultaneously controlling the magnitude of the electron diversion and the intensity of the electron stream to the output electrode.

The novel features which are believed to be characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects thereof, will best be understood by reference to the specification taken in connection with the accompanying drawings, in which Figs. 1, 2, and 3 are circuit diagrams, partially schematic, of different forms of the attenuator system as embodied in a broadcast receiver of the superheterodyne type.

Referring to Fig. 1 of the drawings, there is shown a circuit diagram, partially schematic, of a complete modulated-carrier signal receiver of the superheterodyne type employing the invention. This receiver comprises, in cascade in the signal-translating channel thereof, a receiver input or antenna-ground circuit 10, 11, a preattenuating circuit 12, a vacuum-tube radio-frequency amplifier 13 including an input circuit, a frequency changer or oscillator-modulator 14, an intermediate-frequency amplifier 15 of one or more stages, a detector and automatic amplification control or A. V. C. supply 16, an audio-frequency amplifier 17 of one or more stages, and a sound reproducer 18. The attenuator 12 comprises a coupling circuit for coupling the input circuit of the receiver to the input circuit of vacuum tube 13, which coupling circuit will be subsequently described more fully. Automatic amplification control is secured in a well-known manner by applying a unidirectional voltage derived from the A. V. C. supply 16 over conductor 19 to the control electrodes of oscillator-modulator 14 and of one or more of the tubes included in the intermediate-frequency amplifier 15. Suitable operating potentials are supplied to the tubes of the receiver from sources indicated as +B and +Sc.

Neglecting for the present the operation of the preattenuator of the invention, the apparatus

described constitutes, in general, a conventional superheterodyne radio receiver having a plurality of signal selector circuits, the operation of which is well understood in the art. In brief, signals intercepted by antenna-ground circuit 10, 11 are translated by the selector circuit 12 to the input circuit of radio-frequency amplifier 13, are amplified therein and translated to oscillator-modulator 14 wherein they are converted to an intermediate-frequency signal. The intermediate-frequency signal is amplified in intermediate-frequency amplifier 15 and delivered to detector 16, wherein the audio-frequency signals and the A. V. C. biasing potentials are derived. The audio-frequency signals are, in turn, amplified by audio-frequency amplifier 17 and supplied to sound reproducer 18 for reproduction. The automatic amplification control bias derived from unit 16 is effective to maintain the signal input to detector 16 within relatively narrow limits for a wide range of received signal intensities.

Referring now more particularly to the preattenuator for controlling the input to radio-frequency amplifier 13, the arrangement of Fig. 1 comprises, in general, a normal or first coupling circuit which is one of the selector circuits and is positioned between the antenna-ground circuit 10, 11 and the input circuit to amplifier 13. This first circuit includes a tuned circuit comprising an inductance 20 and a condenser 21, inductance 20 being inductively coupled to inductance 22 in the antenna-ground circuit 10, 11. The low potential terminal of selector circuit 20, 21 is grounded for carrier-frequency currents through a condenser 23, while the cathode of tube 13 is connected to ground through an unby-passed cathode resistor 24. The preattenuator also includes an auxiliary or second coupling circuit between the antenna-ground circuit 10, 11 and the input circuit of amplifier 13 in parallel with the normal coupling circuit and comprising a control tube or vacuum-tube signal repeater 25 having its input circuit for signal energy connected across selector 20, 21 through a condenser 26, its cathode being connected to the cathode of tube 13 and to ground through the cathode-biasing resistor 24. In other words, the output circuit of control tube 25 is coupled across resistor 24 which comprises the major part of the load impedance of this tube. As so connected, the coupling of the auxiliary or second coupling path comprising control tube 25 is such as to develop a potential across resistor 24 in the input circuit of amplifier 13 opposite in phase to the potential coupled directly to the input circuit of amplifier 13 by the normal coupling path comprising the selector circuit 20, 21. The anode circuit of radio-frequency amplifier 13 is coupled to the input circuit of oscillator-modulator 14 and returned directly to its cathode for signal-frequency components through a circuit comprising condenser 27 which effectively by-passes resistor 24 in the output circuit of amplifier 13 for carrier-frequency currents. A decoupling resistor 9 is provided in the anode circuit of tube 13 and a decoupling circuit comprising resistor 9' and condenser 27' is provided in the screen circuit to prevent alternating currents in the anode circuit of tube 13 from flowing through resistor 24.

In order to provide a bias for control tube 25 which varies in accordance with received signal intensities, there is provided an auxiliary amplifying and rectifying channel including vacuum tubes 28 and 29. The input circuit of auxiliary amplifier 28 is coupled to the radio-frequency

channel of the receiver through condenser 26, while its output circuit is coupled through transformer 30, 31 to the diode rectifier 29. Rectifier 29 is provided with a load circuit comprising resistor 32, by-passed for alternating currents by condenser 33, across which there is developed a unidirectional voltage which varies in magnitude in accordance with the amplitude of the signal input to amplifier 28. This voltage is applied positively, through a filter comprising series resistors 34 and shunt condenser 35, to the grid of control tube 25, this bias voltage, together with that of a bias source 32', serving to vary its transconductance. A cathode-biasing circuit 36 is provided for amplifier 28. To provide an automatic amplification control bias for radio-frequency amplifier 13 which is responsive to both desired and undesired received signals, there is provided an auxiliary diode anode 37 in amplifier 28 having coupled to its output circuit a load resistor 38 across which the control-bias voltage is developed. This voltage is applied negatively through a circuit comprising a resistor 39 to the control grid of radio-frequency amplifier 13. In order to neutralize undesirable capacitive coupling effects through the grid-cathode capacitance, a voltage is coupled from a winding 40, which is effectively an extension of winding 20 and coupled thereto, through a neutralizing condenser 41 to the cathode of amplifier 13.

It will be noted that the input circuit of the vacuum-tube repeater 25, and also that of the auxiliary amplifier 28, comprises simply a resistor which, of course, is aperiodic or nonfrequency-selective. Consequently, it may be said that the repeater 25 and amplifier 28 are both nonfrequency-selective and that their input circuits are simply coupled through the coupling condenser 26 to the input circuit or antenna-ground circuit 10, 11 of the receiver. It follows, therefore, that the second coupling circuit comprising vacuum tubes 25, 28 and 29 is also substantially nonfrequency-selective.

In considering the operation of the system just described, it will be assumed that, in the absence of received signals or for signals of a very low amplitude, tube 25 is biased to a low value of transconductance or beyond cutoff, so that the auxiliary or second coupling circuit of the invention is practically inoperative, the entire coupling between the antenna-ground circuit 10, 11 and the input electrodes of radio-frequency amplifier 13 being that of the first or normal coupling circuit comprising selector circuit 20, 21. Under such conditions, the receiver operates in a conventional manner. However, as the amplitude of received signals increases, there is an appreciable signal input to amplifier 28 through condenser 26. The output voltage of amplifier 28 is rectified by diode rectifier 29 to develop a bias potential across load resistor 32 which varies in accordance with the amplitude of received signals. This voltage is applied positively through the filter 34, 35, 34 to the grid of control tube 25 to increase its transconductance. Inasmuch as the signal input to tube 13 through the normal coupling path is in phase opposition to that developed across resistor 24, also in the input circuit to tube 13, by the tube 25 in the auxiliary coupling circuit, an increase in the transconductance of the tube 25 serves to decrease the resultant effective coupling between the antenna-ground circuit 10, 11 and the input circuit of vacuum tube 13; that is, to attenuate the signal input to the first repeater of the receiver. It will be noted that the resistor 24

is effectively an unby-passed degenerative cathode resistor for only tube 25. It will be understood that the selective circuits of the receiver following selector circuit 20, 21 are more frequency selective than selector circuit 20, 21 so that the major portion of the selectivity of the receiver is provided by the circuits in the signal-translating channel succeeding the point to which the attenuation control circuit is coupled. Hence, undesired signals as well as desired signals are included in the input to amplifier 28 so that there may be derived a bias potential which varies in accordance with the amplitude of these signals. A neutralizing voltage from winding 40 coupled through condenser 41 to the cathode of tube 13 serves to eliminate undesirable capacitive coupling through the grid-cathode capacitance of the tube. It will be understood that a filter circuit, or other circuit having a resistive impedance over the band of frequencies for which the circuit is to operate, can be utilized in place of resistor 24.

The embodiment of the invention illustrated in Fig. 2 is similar in many respects to that shown in Fig. 1 and similar elements in the two figures have been given identical reference numerals. The control tube 25 of Fig. 2 is coupled between the antenna-ground circuit 10, 11 and the input circuit of radio-frequency amplifier 13 is coupled in the same manner as in Fig. 1, the difference between the two embodiments being in the source of control bias provided for the control tube 25. In order to provide a control bias for tube 25 of Fig. 2, there is coupled to the output circuit of the control tube through a condenser 50, a rectifier 51 having a load resistor 52, by-passed for high-frequency currents by a condenser 53, in series with an inductance 54. The unidirectional potential developed across resistor 52 is applied positively through a resistor 56 to the control electrode of tube 25. A battery 57 provides an initial negative to bias bias tube 25 to cut off in the absence of received signals. In the embodiment of Fig. 2, radio-frequency amplifier 13 is provided with an automatic volume control potential derived from A. V. C. supply 16 through a filter comprising a series resistor 58 and a shunt condenser 59 in a conventional manner.

It will be seen that the operation of the circuit of Fig. 2 is essentially the same as that of the circuit of Fig. 1, the control tube 25 providing potentials across resistor 24 opposite in phase to those of the normal coupling circuit between the antenna and radio-frequency amplifier 13 in each case. The rectifier 51 coupled to the output circuit of control tube 25 provides a bias potential for control tube 25, thereby to increase its transconductance in accordance with the amplitude of received signals. It will be seen that the automatic volume control of radio-frequency amplifier 13 in Fig. 2 is responsive only to desired received signals. It will also be seen that the embodiment disclosed in Fig. 2 provides the required control-bias potentials for tubes 13 and 25 without the use of an amplifier tube corresponding to tube 23 of Fig. 1.

The embodiment of the invention shown in Fig. 3 utilizes only one vacuum tube to provide both the normal coupling path from the antenna-ground circuit 10, 11 and the auxiliary coupling path for developing signal voltages across cathode-biasing resistor 24 opposite in phase to those impressed on the signal-input grid through the normal coupling path. In the embodiment shown in Fig. 3, this dual purpose tube is shown as radio-frequency amplifier 13, which may be a tube

of the conventional pentode type which includes a main anode, a cathode, an auxiliary anode or screen grid, an input electrode or signal grid and a suppressor electrode here used as a control grid. The control electrode last mentioned is disposed between the main anode and the auxiliary electrode which is normally the screen grid of the tube. In order to control the transmission efficiency of the circuits associated with radio-frequency amplifier 13, there is provided an amplifier 60 having an input electrode coupled across selector 20, 21 through condenser 61. A grid-leak resistor 62 and a cathode-biasing resistor 63, by-passed for alternating currents by a condenser 64, are provided for amplifier 60. The output circuit of amplifier 60 is coupled through a transformer 65, 66 to a diode detector 67 having a load circuit comprising a resistor 68, by-passed for alternating currents by a condenser 69. The voltage developed across resistor 68 is applied negatively to the normal suppressor grid of radio-frequency amplifier tube 13.

In considering the operation of the circuit of Fig. 3, it will be seen that the signal-input grid of radio-frequency amplifier 13 controls the cathode emission of the tube and, in the absence of received signals of an appreciable magnitude to provide a bias for the suppressor grid, the received signals are amplified and delivered to oscillator-modulator 14 in a conventional manner. However, as signals of increasing intensity are received, the voltage developed across resistor 68 and applied negatively to the suppressor grid effectively reduces the amplitude of the signal input to oscillator-modulator 14 and increases the signal component of the auxiliary electrode or screen-grid current. The increase in this signal-frequency screen-grid current effectively develops a degenerative signal voltage across the resistor 24 which is in the output circuit of the auxiliary electrode that is, a signal-input voltage to tube 13 is developed which is opposite in phase to that of the signal voltage due to the normal coupling circuit, thereby attenuating the resultant signal input to radio-frequency amplifier 13 to prevent distortion. The amplifier 60, the detector 67, and the normal suppressor grid of the vacuum tube 13 act as an automatic volume control source and are, therefore, included in a means for varying the transconductance to the auxiliary electrode of vacuum tube 13 in accordance with the intensity of the received signals. This means is, therefore, responsive to received signals for varying the transconductance from the input electrode to the anode in one sense and the transconductance from the input electrode to the auxiliary electrode or anode in an opposite sense. The suppressor grid and the diode detector 67 are, therefore, included in a means for simultaneously controlling the electron flow to the output electrode or anode of tube 13 and regulating the electron current flow to the auxiliary electrode thereby to control the magnitude of the degenerative voltage. The diode detector arrangement is a single means for simultaneously controlling the magnitude of the electron diversion and the intensity of the electron stream to the output electrode or anode of tube 13.

It will be understood that each of the embodiments of the invention described above can be utilized with any suitable control circuit such as one which is responsive to either or both of desired and undesired received signals.

While there have been described what are at present considered the preferred embodiments of

the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode resistor for said vacuum tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, substantially nonfrequency-selective means for developing across said resistor potentials opposite in phase to those developed in said vacuum-tube input circuit by said coupling circuit, and means for varying the effectiveness of said last-named means to vary the intensity of the signal developed in said output circuit.

2. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a first coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode-biasing resistor for said vacuum tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, a second coupling circuit coupled to said input circuit of said receiver and having an output circuit including said resistor, said second coupling circuit developing signal potentials across said resistor opposite in phase to those developed in said vacuum-tube input circuit by said first coupling circuit, and means for varying the transmission efficiency of said second coupling circuit to vary the intensity of the signal developed in said output circuit.

3. In a modulated-carrier signal receiver comprising an input circuit, a vacuum tube having an input circuit, and a plurality of signal selector circuits in the signal-translating channel of said receiver, a first coupling circuit comprising one of said signal selector circuits for coupling said input circuit of said receiver to said input circuit of said vacuum tube, said one of said selector circuits being less frequency-selective than others of said selector circuits, a cathode-biasing resistor for said tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, a second coupling circuit having an output circuit including said resistor and developing potentials across said resistor opposite in phase to those developed in said vacuum-tube input circuit by said first coupling circuit, said second coupling circuit being substantially nonfrequency-selective, and means for controlling the transmission efficiency of said second coupling circuit in accordance with the amplitude of received signals.

4. In a modulated-carrier signal receiver tunable over a wide range of signal frequencies comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of said receiver, a first coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode-biasing resistor for said tube, said vacuum

tube having an output circuit returned for signal-frequency components directly to its cathode, a second coupling circuit having an output circuit including said resistor, said second coupling circuit being substantially nonfrequency-selective over said range and being poled to provide a coupling of opposite phase to that of said first coupling circuit in the input circuit of said vacuum tube, and means for controlling the transmission efficiency of said second coupling circuit to vary the intensity of the signal developed in said output circuit.

5. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a first coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode resistor for said tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, a second coupling circuit having an output circuit including said resistor and developing potentials across said resistor opposite in phase to those developed in said vacuum-tube input circuit by said first coupling circuit, an auxiliary amplifier coupled to said input circuit of said tube, rectifying means coupled to said amplifier for deriving a bias potential varying in accordance with the amplitude of the desired and undesired signal input to said tube, and means for utilizing said bias potential to control the transmission efficiency of said second coupling circuit.

6. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a first coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode-biasing resistor for said vacuum tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, a second coupling circuit comprising a vacuum-tube signal repeater coupled between said input circuit of said receiver and said input circuit of said tube, said vacuum-tube repeater having an output circuit including said resistor, and means for controlling the transconductance of said repeater to vary the intensity of the signal developed in said output circuit.

7. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a first coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a second coupling circuit comprising a vacuum-tube signal repeater coupled between said input circuit of said receiver and said input circuit of said tube, a common cathode-biasing resistor for said tube and said vacuum-tube signal repeater, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, said resistor comprising substantially the entire load impedance of said vacuum-tube signal repeater, and means for controlling the transconductance of said repeater to vary the intensity of the signal developed in said output circuit.

8. In a modulated-carrier signal receiver comprising an input circuit, a plurality of vacuum tubes having input circuits, and a plurality of signal selector circuits in the signal-translating

channel of said receiver, a first coupling circuit comprising one of said signal selector circuits for coupling said input circuit of said receiver to said input circuit of one of said vacuum tubes, said one of said selectors being less frequency-selective than others of said selectors, a second coupling circuit comprising a vacuum-tube signal repeater coupled between said input circuit of said receiver and said input circuit of said one of said tubes, a cathode-biasing resistor for said one of said tubes, said one of said vacuum tubes having an output circuit returned for signal frequencies directly to its cathode, said vacuum-tube repeater having an output circuit including said resistor, said second coupling circuit being substantially nonfrequency-selective, and means for controlling the transconductance of said repeater to vary the intensity of the signal developed in said output circuit.

9. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a first coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode-resistor for said tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, a second coupling circuit comprising a vacuum-tube signal repeater coupled between the said input circuit of said receiver and said input circuit of said tube, said vacuum-tube repeater having an output circuit including said resistor, rectifying means coupled to the output circuit of said vacuum-tube repeater for deriving a bias potential varying in accordance with the amplitude of the desired and undesired signal input to said one of said tubes, and means for utilizing said bias potential to control the transconductance of said vacuum-tube signal repeater.

10. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a first coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode-resistor for said tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, a second coupling circuit comprising a vacuum-tube signal repeater coupled between said input circuit of said receiver and said input circuit of said tube, said vacuum-tube signal repeater having an output circuit including said resistor, means responsive to the input to said one of said tubes for developing bias potentials varying in accordance with the amplitude of the input to said tubes, means for applying one of said potentials positively to said vacuum-tube repeater to vary its transconductance, and means for applying one of said potentials negatively to said first-named vacuum tube as an automatic amplification control bias.

11. In a modulated-carrier signal receiver comprising an antenna circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, a cathode-biasing resistor for said tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, an auxiliary electrode in said vacuum tube having an output circuit effec-

tively including said resistor for signal-frequency currents, whereby there is developed across said resistor signal potentials opposite in phase to those developed in said vacuum-tube input circuit by said coupling circuit, and means for varying the transconductance of said auxiliary electrode with respect to said vacuum-tube input circuit in accordance with the intensity of received signals.

12. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, said vacuum tube comprising a main anode, an input electrode, and an auxiliary electrode, a cathode-biasing resistor for said vacuum tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, said auxiliary electrode having an output circuit effectively including said resistor for signal-frequency currents, whereby there is developed across said resistor signal potentials opposite in phase to those developed in said vacuum-tube input circuit by said coupling circuit, and means responsive to received signals for varying the transconductance from said input electrode to said anode in one sense and the transconductance from said input electrode to said auxiliary electrode in an opposite sense.

13. In a modulated-carrier signal receiver comprising an antenna circuit, a vacuum tube having an input circuit, and an automatic volume control source, an attenuator comprising a coupling circuit for coupling said antenna circuit to said input circuit of said vacuum tube, said vacuum tube comprising an anode, an input electrode, and an auxiliary electrode, a cathode-biasing resistor for said vacuum tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, said auxiliary electrode having an output circuit effectively including said resistor for signal-frequency currents, whereby there is developed across said resistor signal potentials opposite in phase to those of said coupling circuit, and means responsive to said automatic volume control source for varying the transconductance from said input electrode to said anode in one sense and the transconductance from said input electrode to said auxiliary electrode in the opposite sense.

14. In a modulated-carrier signal receiver comprising an input circuit and a vacuum tube having an input circuit in the signal-translating channel of the receiver, an attenuator comprising a coupling circuit for coupling said input circuit of said receiver to said input circuit of said vacuum tube, said vacuum tube comprising a signal grid, a control grid, an anode and an auxiliary electrode, said control grid being disposed between said anode and said auxiliary electrode, a cathode-biasing resistor for said tube, said vacuum tube having an output circuit returned for signal-frequency components directly to its cathode, said auxiliary electrode having an output circuit effectively including said resistor for signal-frequency currents, whereby there is developed across said resistor signal potentials opposite in phase to those developed in said vacuum-tube input circuit by said coupling circuit, and means responsive to the amplitude of received signals for applying a potential to said control electrode to vary the transconductance from said

signal grid to said anode in one sense and the transconductance from said signal grid to said auxiliary electrode in the opposite sense.

15. In a radio receiver, a signal transmission tube including at least a control grid, a cathode and an output electrode, an impedance connected between the tube cathode and ground, means for applying signal energy between the tube control grid and ground, a signal output circuit connected directly between the control grid and cathode of said tube, and means for applying a variable unidirectional voltage to said control grid, thereby to vary the signal output voltage amplitude between said control grid and cathode.

16. In a radio receiver, a signal transmission tube, means for applying signal energy between the control grid and cathode of the tube, an output circuit connected directly between the control grid and cathode of the tube, an impedance disposed in the space current path of said tube, means connecting said control grid and cathode of said tube across points of said impedance such that the signal voltage developed across the impedance is applied in degenerative phase between the two electrodes, and means for varying the gain of said tube thereby to vary the signal voltage amplitude delivered to said output circuit.

17. In an amplifier of the type including a tube provided with at least an electron emission source, an input electrode and an output electrode; the method including impressing waves upon said input electrode, developing amplified wave voltage at said output electrode, diverting electrons flowing from said source to said output electrode, deriving from the diverted electron flow a wave voltage, combining the derived wave voltage and impressed waves in phase opposition, and concurrently regulating the relative amplitudes of said derived voltage and amplified voltage in opposed senses.

18. In a signal transmission network provided with a tube having an electron emission source, an input electrode, an output electrode, and an auxiliary electrode; the method which includes establishing said input electrode at a negative potential relation to said emission source, impressing signals upon said input electrode, deriving at said output electrode amplified signals, deriving a signal voltage from electron flow to said auxiliary electrode, impressing said derived signal voltage upon the input electrode, and controlling the distribution of electrons from said source between said output electrode and said auxiliary electrode.

19. In a signal amplifier, a tube provided with a cathode, a negative signal grid, an output electrode and a positive auxiliary electrode arranged to receive electrons from said cathode, a signal

source coupled between the cathode and signal grid, means operatively associated with the auxiliary electrode to develop signal voltage and impress it in degenerative phase upon said signal grid, an output circuit connected to said output electrode, and means for simultaneously controlling the electron flow to said output electrode and regulating the electron current flow to said auxiliary electrode thereby to control the magnitude of said degenerative voltage.

20. In a signal amplifier, a tube provided with a cathode, a signal grid, an output electrode and an auxiliary electrode arranged to receive electrons from said cathode, a control electrode disposed in said tube between said output electrode and auxiliary electrode, a signal source coupled between the cathode and signal grid, means operatively associated with the auxiliary electrode to develop signal voltage and impress it in degenerative phase upon said signal grid, an output circuit connected to said output electrode, and means including said control electrode for regulating the electron current flow to said auxiliary electrode thereby to control the magnitude of said degenerative voltage.

21. In a signal amplifier, a tube provided with a cathode, a negative signal grid, an output electrode and a positive auxiliary electrode arranged to receive electrons from said cathode, a signal source coupled between the cathode and signal grid, means operatively associated with the auxiliary electrode to develop signal voltage and impress it in degenerative phase upon said signal grid, an output circuit connected to said output electrode, and means for simultaneously controlling the electron flow to said output electrode and regulating the electron current flow to said auxiliary electrode thereby to control the magnitude of said degenerative voltage, said first named means including an impedance connected between said auxiliary electrode and the cathode, and a path of low impedance to signal voltage connecting the signal grid to a point on said impedance.

22. In combination with a tube provided with at least a cathode, signal input electrode and output electrode, a signal input circuit coupled to the input electrode, a signal output circuit connected to the output electrode, means, responsive to electrons diverted from the electron stream flowing between cathode and output electrode, for developing signal voltage, means applying the developed signal voltage to said input electrode in degenerative phase relative to the signal voltage from said input circuit, and a single means for simultaneously controlling the magnitude of said electron diversion and the intensity of the electron stream to said output electrode.

HAROLD M. LEWIS.

CERTIFICATE OF CORRECTION.

Patent No. 2,313,952.

March 16, 1943.

HAROLD M. LEWIS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, first column, line 41, for the words "to bias bias" read --bias to bias--; and second column, line 41, after "electrode" insert a semicolon; page 6, first column, lines 38 and 57, claims 9 and 10 respectively, strike out "one of said"; line 63, claim 10, for "vacumu" read --vacuum--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of May, A. D. 1943.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.