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AUTOMATIC VOLUME CONTROL CIRCUIT

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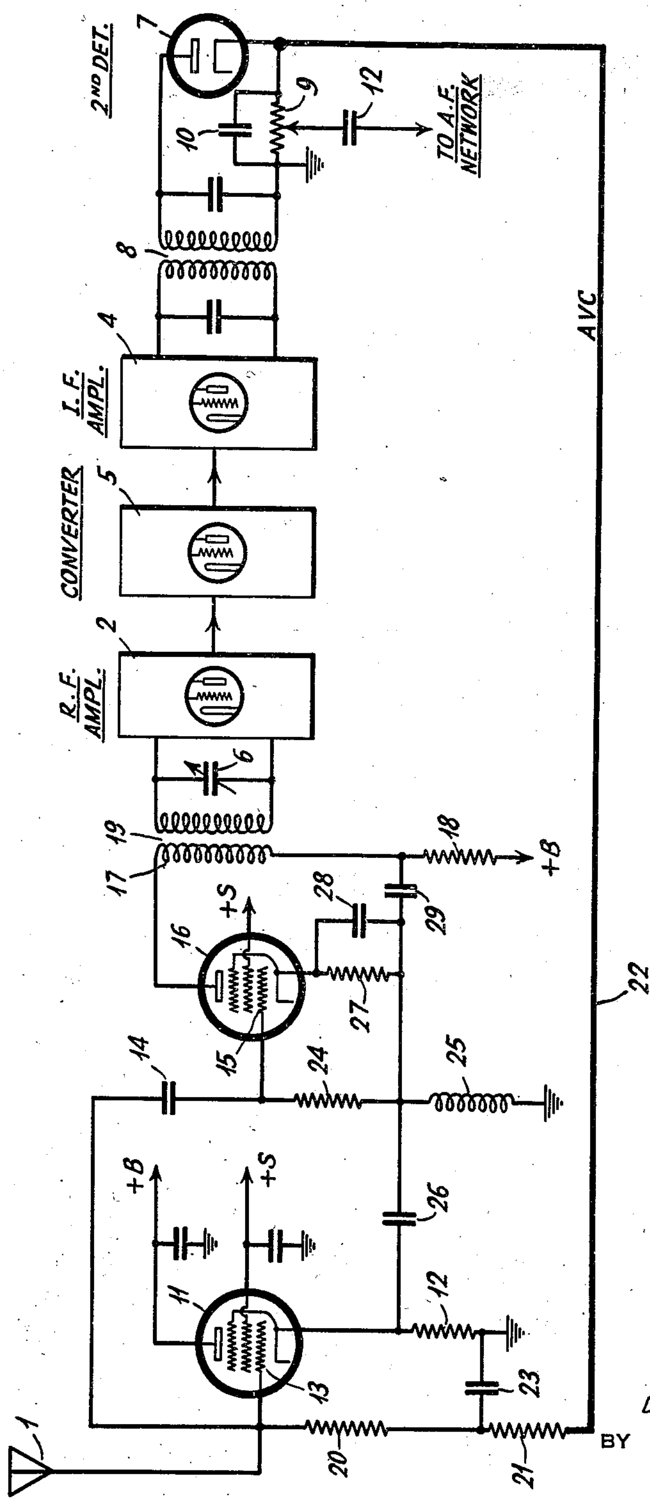

INVENTOR
DUDLEY E. FOSTER
BY H. S. Grover
ATTORNEY

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AUTOMATIC VOLUME CONTROL CIRCUIT

Dudley E. Foster, South Orange, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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8 Claims. (Cl. 250—20)

My present invention relates to automatic gain control circuits for radio receivers, and more especially to automatic volume control circuits which function to maintain the receiver output substantially uniform.

One of the main objects of my present invention is to provide an automatic volume control circuit for a radio receiver, and wherein the control circuit employs, between the signal collector and the high frequency amplifier, a tube having a network between its input electrodes such that signal energy is opposed to a degenerative potential, the resultant being fed to the high frequency amplifier, and the magnitude of the resultant potential being under the control of the carrier amplitude.

Another important object of my invention is to provide a method of controlling the volume of a radio receiver, which method includes the step of utilizing received signals to develop a potential in degenerative phase, feeding the resultant through the receiving system, and controlling the magnitude of the resultant potential in response to changes in carrier amplitude.

Still other objects of the invention are to improve generally the simplicity and efficiency of automatic volume control circuits for radio receivers, and more especially to provide circuits employing degenerative action, and which circuits are not only reliable in operation, but economically manufactured and assembled in radio receivers.

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

Referring now to the accompanying drawing, wherein is shown a conventional superheterodyne receiver employing the invention, it will be observed that the receiver comprises the usual networks. The signal collector 1 is employed to collect modulated signal energy, and it is to be understood that the modulated signals may be included in the broadcast band of 500 to 1500 kc. Of course, if the receiver is of the multi-wave type, then the collected signals will be included over these various bands. The collector 1 may be of the grounded antenna type; a radio frequency distribution line; a loop collector, or even a collector employed on a mobile structure. The collected signals are transmitted, through a network to be described at a later point, to the tunable radio frequency amplifier 2, and then to an I. F. (intermediate frequency) amplifier 4 through a converter network 5. The converter comprises the usual tunable first detector and local oscillator circuit, and it will be understood that the reference numeral 6 denotes the usual tuning condenser which is employed in the signal and local oscillator tank circuits.

The output of the I. F. amplifier 4 is impressed upon a diode demodulator 7 through an I. F. transformer 8, whose primary and secondary circuits are each fixedly resonated to the predetermined operating I. F. value. The demodulator 7, which is the second detector of the receiver, includes the usual load resistor 9 in series between the cathode and the grounded side of the demodulator input circuit, the resistor 9 being shunted by I. F. by-pass condenser 10. The modulation component of the voltage developed across resistor 9 is impressed upon one or more audio frequency amplifiers through an audio frequency transmission path 12. Of course, the final audio amplifier will feed its output energy to any desired form of reproducer.

It is to be clearly understood that the receiver of the circuit need not necessarily be of the superheterodyne type; it may be of the tuned radio frequency type. In that case, the various radio frequency amplifiers will have their input circuits tunable in unison to various signal frequencies in the operating frequency range. In order to maintain the signal carrier amplitude at the demodulator input circuit substantially uniform regardless of a wide range of carrier amplitude variation at the collector 1, there is customarily employed an automatic volume control (AVC) circuit. In the past, such AVC action has been accomplished by employing the direct current voltage component of rectified signals of one or more signal amplifiers. In such type of AVC circuit, as the carrier amplitude increases the signal grids of the controlled amplifiers are biased increasingly negative thereby to reduce the gain in each amplifier.

In the present arrangement AVC action is secured by a form of signal-controlled degenerative feedback. The present AVC circuit comprises a tube 11 which has its cathode connected to ground through a resistor 12; the signal control grid 13 of the tube is connected, through condenser 14, to the signal control grid 15 of a second tube 16. This tube 16 can be the first tunable radio frequency amplifier. The plate and screen grid of tube 11, which may be of the pentode type, are connected to sources of positive potential, and it will be observed that the plate and screen grid of tube 16 are also energized from positive potential points. The plate of tube 16 is connected to its point of positive potential through a path which includes the coil 17 and resistor 18. The coil 17 is the primary winding of transformer 19, the secondary of the latter being in the tunable input circuit of the radio frequency amplifier 2. Of course, a common source of positive potential can be used to energize the screen grid electrodes and plate electrodes of tubes 11 and 16.

The control grid 13 of tube 11 is connected to the cathode side of load resistor 9 through a path which includes resistor 20, resistor 21 and lead 22; the lead 22 is designated by the reference letters "AVC" to denote that this is the automatic volume control connection. The junction of resistors 20 and 21 is connected to the grounded side of resistor 12 through a condenser 23. The cathode side of resistor 12 is connected to the junction of resistor 24 and coil 25 through a condenser 26; the junction of the latter two elements is connected to the cathode resistor 27 of tube 16, the resistor 27 being shunted by a signal frequency by-pass condenser 28.

One terminal of the series path including resistor 24 and coil 25 is connected to the grid side of condenser 14, whereas the other terminal of the path is established at ground potential. Appropriate by-pass condensers are employed to by-pass the energizing leads connected to the positive electrodes of tubes 11 and 16.

Resistor 20 is the impedance across which the antenna to ground (which is the same as grid 13 to ground) voltage is developed. Resistor 21 is a filter resistor; this resistor in conjunction with capacity 23 allows the direct current voltage developed across resistor 9 to be impressed on grid 13, but prevents any of the alternating voltage components across resistor 9 from being impressed on grid 13. Resistor 24 supplies the bias voltage (due to the drop across resistor 27) to tube 16. Resistor 18 is a radio frequency isolating resistor so that the R. F. (radio frequency) from the plate circuit of tube 16 returns to cathode through the condenser 29 and condenser 28, rather than through the B supply. If it returned through the B supply, choke 25 and resistor 12 would be short-circuited as far as R. F. was concerned and no degeneration would occur. A choke similar to 25 could be used in place of resistor 18.

Coil 25 is an R. F. choke to present a low resistance D. C. (direct current) path for the plate current of tube 16 to return to the cathode thereof, but presents a high impedance to R. F. currents in the grid circuit so that the input R. F. will flow from the cathode of tube 11 through condenser 26 to tube 16 and thus give the desired degenerative action. If choke 25 were absent the signal energy between grid and ground would be applied directly to the input of 16, and not be controlled by tube 11.

The signal current in the antenna circuit follows the following path: antenna 1, resistor 20, condenser 23 to ground. Condenser 23 provides a low impedance path for R. F., but blocks the D. C. so that the bias of grid 13 is the D. C. developed across resistor 9 by the signal, and not the D. C. across resistor 12. Condenser 23 is thus in the antenna-ground path and the grid-cathode path of tube 11. It should be sufficiently large, say of the order of 0.1 mf. (microfarads). It functions as a blocking and by-pass condenser. The ground connection for antenna 1 is the ground at the bottom of resistor 12. A separate ground at the bottom of resistor 20 could be provided, but should be isolated to D. C. by a condenser. Since condenser 23 is already present, grounding the antenna at the point shown makes capacity 23 doubly useful.

In operation, when the signal carrier amplitude increases, the cathode side of resistor 9 will increase in positive potential with respect to ground. As a result, the signal grid 13 will be biased in a positive sense, and cause the tube 11 to become conductive. It will be understood that the resistor 12 has a magnitude such that there is substantial cut-off bias applied to grid 13 in the absence of signals. Hence, when signals are received, the tube 11 increases in conductivity and current flows through resistor 12. This results in the signal intensity at the input of tube 16 being reduced.

This can be readily understood when it is realized that there is impressed upon grid 13 signal voltage in degenerative phase by virtue of the voltage drop across resistor 12. When weak signals are being received, then the signal potential difference between the control grid 13 and ground is a maximum. As the signal intensity increases, however, the mutual conductance of tube 11 increases by virtue of the positive potential impressed on grid 13 through lead 12, and causes an increasing flow of current through resistor 12. Since the voltage across 12 is impressed upon grid 13 in degenerative phase with respect to the signal potential impressed thereon from the collector 1, it follows that an increase in carrier amplitude will cause the effective signal potential difference between grid 13 and ground to be decreased. The development of degenerative voltage across resistor 12 is chosen so that the signal carrier amplitude at the demodulator input circuit will be substantially uniform.

The effective voltage at the control grid 13 of tube 11 is impressed upon the input electrodes of tube 16, and the amplified output of tube 16 is transmitted through the following stages. It will, therefore, be seen that the potential difference between the control grid and cathode of tube 11 varies inversely with the mutual conductance, or transconductance, of tube 11, and the control of the latter is developed at the detector load resistor. Hence, when the mutual conductance of tube 11 is high, the potential difference between the input electrodes of tube 11 is low. The arrangement shown has the advantage in that there will be freedom from cross-modulation, because when the signal input to the receiver is large, the tube 11 will be operating on the straight portion of its characteristic.

More specifically, the operation is as follows: In the absence of signals the D. C. plate current of tube 11 flows into the B supply and returns to the cathode through resistor 12 and develops a bias thereacross, which bias is applied to grid 13 by way of resistors 9, 21 and 20. With this bias, which can be made close to cut-off bias of tube 11, substantially all of the signal voltage developed across resistor 20 will likewise appear between grid and cathode of tube 11, and, therefore, be transmitted to the input of amplifier tube 16. This is under conditions of small signal on the antenna, which might, for example, develop 0.5 volt across resistor 9. This small positive voltage will cause only a small increase in mutual conductance of tube 11, and, therefore, will produce only a small amount of degeneration. This small change in gain at small signals is more true on this type of AVC than on the conventional type because the controlled tube (in this case tube 11) is operating near cut-off, and the curvature of the tube characteristic in that region means that an appreciable change in bias voltage is necessary before the mutual conductance changes greatly. With larger signals applied, voltages are developed across resistor 9 of sufficient magnitude to cause an appreciable change in mutual conductance of tube 11. When the mutual conductance of tube 11 is high a large R. F. voltage will appear across resistor 12 which opposes, or degenerates, the input R. F. voltage so that the net voltage appearing between grid and cathode of tube 11 is decreased from the magnitude applied to the input of that tube. The grid-cathode voltage of tube 11 is applied to the amplifier input (input to tube 16), and, therefore, changes in mutual conductance of tube 11 serve to control the signal applied to grid of tube 16. As shown in the figure this control may be made automatic by using the D. C. developed by the second detector.

In order to illustrate the constants of the circuit which may be used, and it being understood that such constants are in no way restrictive, the following table of magnitudes is given:

Resistor 20=5000 ohms
Resistor 21=500,000 ohms
Resistor 12=50,000 ohms
Resistor 18=50,000 ohms

It is to be understood that a tunable input circuit may be connected between the input electrodes of tube 16, if desired. Further, the condenser 26 and coil 25 may be omitted if the change in bias on grid 13 of tube 11, under AVC action, does not change the operating potential of tube 16 too greatly.

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

What I claim is:

1. In a radio 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 automatically responsive to variations in amplitude level of received signals for varying the gain of said tube thereby to vary the signal voltage amplitude delivered to said output circuit.

2. In a radio receiver, a signal transmission tube, means applying signals between the input electrodes of the tube, a second tube, a network connected directly between the input electrodes of the first tube and the input electrodes of the second tube, an impedance disposed in the space current path of the first tube, said input electrodes of the first tube being connected to points on the impedance such that signal voltage developed across the impedance is impressed in degenerative phase between the input electrodes of said first tube, and means for varying the gain of said first tube in response to variations in carrier amplitude of said received signals.

3. In a radio receiver, a tube having at least a cathode, grid and cold electrode, an antenna including a resistive impedance connected between the grid and cathode, impedance means in the space current path of said tube for deriving a voltage from signal voltage impressed between said grid and cathode, means for impressing said derived voltage in series with said resistive impedance in degenerative phase to the impressed signal voltage, a second tube having input and output electrodes, and means connecting the second tube input electrodes directly across said resistive impedance.

4. In a radio receiver, a tube having at least a cathode, grid and cold electrode, an antenna including a resistive impedance connected between the grid and cathode, impedance means in the space current path of said tube for deriving a voltage from signal voltage impressed between said grid and cathode, means for impressing said derived voltage in series with said resistive impedance in degenerative phase to the impressed signal voltage, a second tube having input and output electrodes, means connecting the second tube input electrodes directly across said resistive impedance, and means, responsive to an increase in signal carrier amplitude, for increasing the magnitude of said derived voltage.

5. In a wave receiving system, a tube having at least a cathode, a grid and a plate, an impedance connected between cathode and ground, a source of waves connected between the grid and ground, a wave utilization network coupled solely between said grid and cathode, said impedance developing thereacross voltage of wave frequency, means impressing said developed voltage upon said grid in degenerative phase, and means for automatically increasing the gain of said tube as the wave amplitude increases thereby to increase the magnitude of the degenerative voltage.

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 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 responsive to the intensity of received signals for varying the effectiveness of said last-named means directly in accordance therewith.

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 coupler 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, rectifying means coupled to said signal-translating channel for deriving a bias potential varying in accordance with the amplitude of received signals, and means for utilizing said bias potential to control the transmission efficiency of said second coupling circuit.

8. 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 being effectively by-passed for alternating currents in the anode circuit of said vacuum tube, and means for controlling the transconductance of said repeater in accordance with the amplitude of received signals.

DUDLEY E. FOSTER.