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AUTOMATIC VOLUME CONTROL RECEIVER

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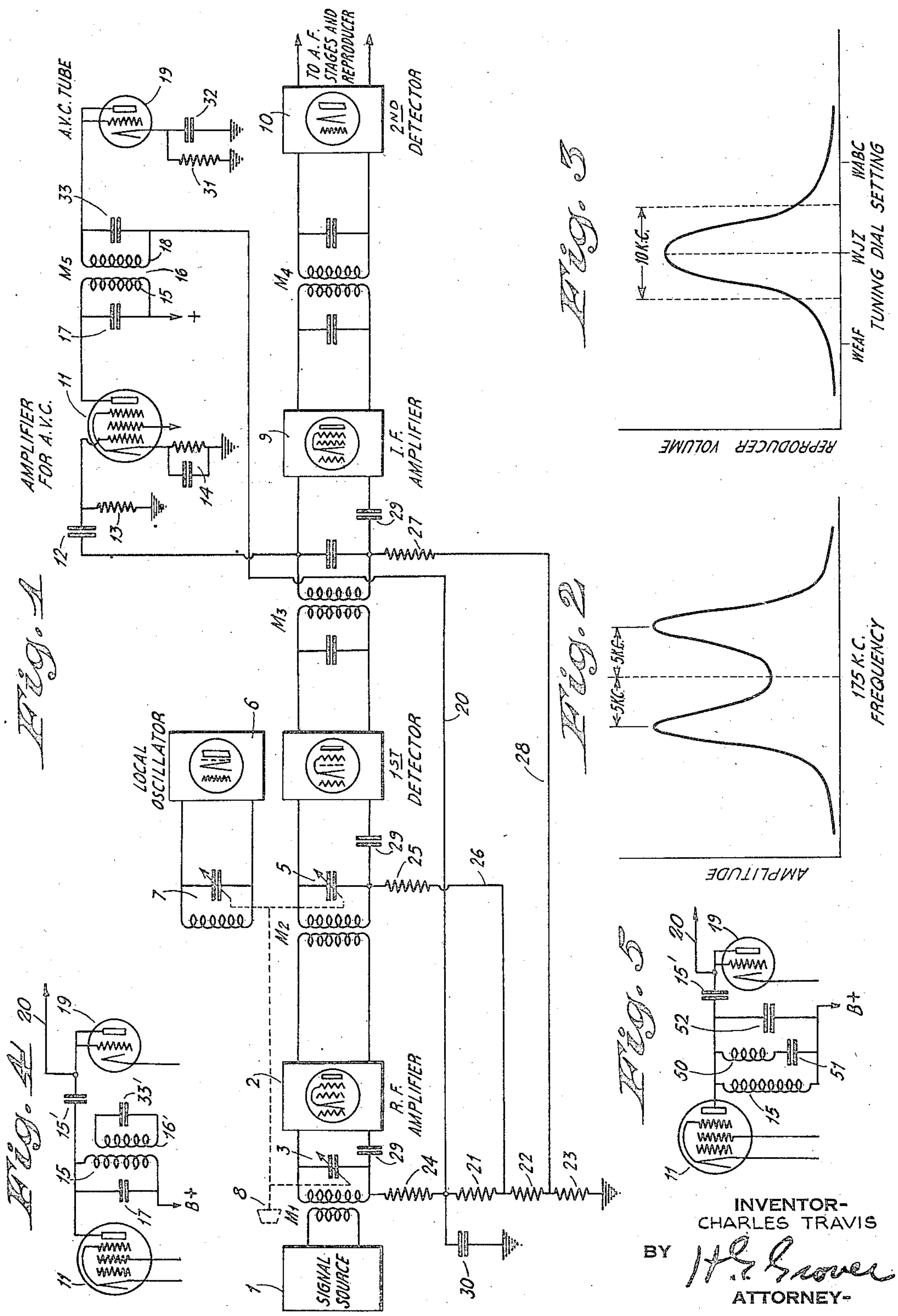

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AUTOMATIC VOLUME CONTROL RECEIVER

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14 Claims. (Cl. 250—20)

My present invention relates to radio receivers, and more particularly to a radio receiver of the type employing automatic volume control wherein the apparent tuning selectivity of the receiver is greatly increased.

It has been found in tuning radio receivers employing automatic volume control that a certain degree of distortion results in determining the desired signal carrier setting on the tuning dial when only the ear of the said operator is relied upon. This distortion is best explained as resulting from an apparent diminution in reproducer volume at the tuning dial setting corresponding to the desired signal carrier, and a relative increase in reproducer volume on either side of the last mentioned dial setting. The tendency, therefore, exists to adjust the tuning dial of the receiver to a point on either side of the desired carrier setting in the mistaken belief that either of such points is the true signal carrier dial setting. This, of course, results in distortion because of cutting of modulation side bands.

It has, therefore, been proposed to employ a visual device, such as a tuning meter, at some point in the receiver which is responsive to the modulated signal carrier energy being detected. The use of such a tuning meter provides a visual check on the ear of the operator with the result that the tuning dial may be adjusted to that setting at which a reading on the tuning meter corresponds to a predetermined signal carrier point, such a point usually being an intermediate point on the tuning meter scale. However, the employment of a tuning meter requires the introduction into the set of additional wiring, and requires a certain degree of attention on the part of the said operator which the average broadcast receiver user is not very willing to give.

Now, I have discovered a method of, and means for, tuning a radio receiver employing automatic volume control, which method utilizes a coupling network prior to the automatic volume control device, possessing a resonance characteristic such that the ear of the said operator may be utilized for accurately determining when the tuning dial has been adjusted to the desired signal carrier setting, thereby eliminating the need for the use of any instrumentality, such as a visual tuning meter, other than the operator's ear for accurately tuning a radio receiver of this type.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a radio receiver employing an automatic volume control circuit having its input coupled in such a manner to a radio frequency portion of the receiver that the resonance curve of the input circuit of the volume control includes a double peak and a pronounced depression between the two peaks corresponding to a desired signal carrier frequency.

Another important object of the present invention is to provide a radio receiver of the type utilizing a frequency changer circuit for producing an intermediate frequency, an intermediate frequency amplifier, an automatic volume control tube, and an automatic volume control amplifier for amplifying a portion of the input to the intermediate frequency amplifier, the circuit of the automatic volume control tube and the output circuit of the automatic volume control amplifier being substantially overcoupled.

Another object of the present invention is to provide a superheterodyne receiver of the type employing a radio frequency amplifier, a first detector, a local oscillator, an intermediate frequency amplifier, and a second detector, wherein the input of the intermediate frequency amplifier is additionally connected to a network including an amplifier and an automatic volume control tube of the diode type, there being connections between the anode circuit of the volume control diode and the input circuits of the radio frequency amplifier and the intermediate frequency amplifier whereby the gain of the latter may be automatically controlled in response to variations of the signal carrier energy level, the coupling between said control network amplifier and control diode being such that the receiver operator may readily and accurately tune the receiver by ear to a desired signal carrier setting.

And still other objects of the present invention are to improve generally the simplicity and tuning efficiency of radio receivers utilizing automatic volume control, and to particularly provide such a receiver which is not only reliable in operation, but economically manufactured and assembled.

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 several circuit organizations whereby my invention may be carried into effect.

In the drawing,

Fig. 1 diagrammatically shows a superheterodyne receiver of the automatic volume control type which embodies the present invention,

Fig. 2 graphically demonstrates the resonance characteristic of the input to the volume control tube,

Fig. 3 graphically shows the operation of the receiver of Fig. 1,

Fig. 4 diagrammatically shows a modification of the invention, and

Fig. 5 shows still another modification.

Referring now to the accompanying drawing wherein like reference characters designate similar circuit elements in the different figures, the superheterodyne receiver conventionally shown in Fig. 1 comprises a signal source 1 which may be the usual antenna circuit, a radio frequency distribution system, or any other well known type of broadcast signal collecting device. The source 1 is coupled, as at M_1, to the tunable input circuit of a radio frequency amplifier 2, the input circuit including a variable tuning condenser 3. The output circuit of the amplifier 2 is coupled, as at M_2, to the tunable input circuit of the first detector 4, a variable tuning condenser 5 being connected in the input circuit of the latter.

A local oscillator 6 is shown in generalized form as being arranged for coupling to the first detector circuit so that the locally generated oscillations may be impressed upon the first detector, or frequency changer, to produce the desired intermediate frequency in the output circuit of the first detector. The local oscillator 6 includes a tuned circuit having the tuning condenser 7 therein, and any well known type of mechanical uni-control 8, shown in dotted lines, may be employed for simultaneously adjusting the tuning condensers 3, 5 and 7.

Reference is had to U. S. Patent 1,740,331 to W. L. Carlson issued December 17, 1929 to show a preferred method of arranging the tunable circuits of the amplifier 2, first detector 4, and local oscillator 6 in order to produce in the output circuit of the detector 4 a constant desired intermediate frequency while simultaneously adjusting the tuning condensers 3, 5 and 7. The output circuit of the first detector 4 is coupled, as at M_3, to the input circuit of the intermediate frequency amplifier 9, and the input circuit of the second detector 10 is coupled to the output circuit of the amplifier 9 through a coupling transformer M_4.

The coupled circuits between the first detector 4 and the amplifier 9, as well as between the amplifier 9 and the second detector 10, are all maintained fixedly tuned to the intermediate frequency, which may be 175 kilocycles. The transformers M_3 and M_4 are preferably both tuned to 175 kilocycles and the circuits are broadly peaked. The output of the second detector 10 may be utilized in any well known manner. Preferably, the output may be impressed upon a first stage of audio frequency amplification, a push-pull type if desired, and finally upon a stage of class B push-pull output amplification, the reproducer of course, being coupled to the output circuit of the final audio amplifier stage.

The automatic volume control network comprises an amplifier tube 11 having its control grid coupled, as through condenser 12, to the grid side of the amplifier 9, the grid of the tube 11 being connected to ground through a resistor 13. The grounded lead of the cathode of tube 11 includes the usual grid biasing resistor-shunt condenser network 14, and the anode of the tube is arranged for connection to a positive source of anode potential through the primary 15 of the coupling transformer 16. A condenser 17 is connected in shunt with the primary coil 15 for fixedly tuning the output circuit of the amplifier 11 to the intermediate frequency.

The secondary 18 of the transformer 16 is connected between the anode of the automatic volume control tube 19 and ground through a path which includes the lead 20, the resistor 21, the resistor 22, and the resistor 23. The lead 20 is additionally connected, through a resistor 24, to the low potential side of the input circuit of the amplifier 2. It will also be noted that the low potential side of the input circuit of the first detector 4 is connected, through a resistor 25 and lead 26, to the junction of resistors 21 and 22, while the low potential side of the input circuit of the intermediate frequency amplifier 9 is connected through a resistor 27 and a lead 28 to the junction of resistors 22 and 23.

Direct current blocking condensers 29 are disposed in the cathode sides of the input circuits of the amplifier 2, the detector 4 and the amplifier 9, and a radio frequency by-pass condenser 30 is connected to ground from the junction of the resistors 24 and 21.

The control tube 19 is shown as a triode, with its control grid strapped to the anode, the tube therefore functioning as a diode rectifier. The cathode of the tube 19 is grounded through a bias resistor 31, the resistor 31 being shunted by a by-pass condenser 32. The transformer secondary 18 is shunted by a condenser 33 which maintains the input circuit of the detector 19 fixedly tuned to the intermediate frequency. The symbol M_5 denotes the fact that the resonant primary and secondary circuits of transformer 16 are very closely coupled, and preferably sufficiently overcoupled to result in a resonance curve characteristic of the type shown in Fig. 2.

The automatic volume control network shown in Fig. 1, as stated heretofore, employs a two element control tube and a special intermediate frequency amplifier to drive it. Due to its action the radio frequency voltage applied to the second detector 10 is substantially constant, for a signal of from 100 microvolts input to that of several volts. Referring to the schematic circuit shown in Fig. 1 it will be noted that the volume control network functions in the following manner. The input signal voltage for the intermediate frequency amplifier 9 is applied also to the control amplifier tube 11 due to the grids of both amplifiers being coupled together by means of the condenser 12.

The output of the amplifier 9 is applied to the second detector through a partially tuned transformer. However, the output of the volume control amplifier 11 is coupled to the control tube 19 through an overcoupled transformer circuit. The drop across resistors 21, 22 and 23 gives the control bias for the radio frequency amplifier 2. The drop across resistors 22 and 23 comprises the control grid voltage for the first detector 4, and that across 23 provides the control grid voltage for the intermediate frequency amplifier 9.

As the drop in these resistors is due to the signal voltage applied to the tube 19, and this voltage is in turn dependent upon the bias of the radio frequency amplifier, first detector and intermediate frequency amplifier, an automatic gain control action is obtained.

The reason for the greater voltage applied to the radio frequency amplifier and the first detector than that applied to the intermediate frequency amplifier **9** is to prevent overloading of these tubes on the side of a strong carrier. The resistors **24**, **25** and **27** function as filter resistors, and substantially suppress any ripples which may exist in the direct current potential. It will now be seen that as the tuning mechanism **8**, which is to be understood as being associated with a tuning dial, is being adjusted to a desired signal carrier dial setting, such as WJZ for example, it is extremely advantageous to have the relation between the receiver reproducer volume and the tuning dial adjustment comprise the curve shown in Fig. 3.

It will be observed from this latter curve that the greatest reproducer response occurs at the peak of the curve which is the signal carrier frequency, and that the reproducer response decreases sharply on either side of the carrier. Obviously, with this type of a relation the ear of the receiver operator can be readily employed to determine when the receiver tuning means is adjusted at the desired signal carrier. The relation shown in Fig. 3 cannot be secured without the employment of my present invention, and it will be noted that it can be secured in a simple and effective manner by merely overcoupling the primary and secondary circuits of the transformer **16** so as to impart to these two circuits a resonance curve of the type shown in Fig. 2.

An examination of this curve demonstrates that each peak of the curve is spaced five kilocycles from the 175 kilocycle carrier, and that the depression of the curve occurs at the carrier frequency. With the transformer primary and secondary circuits between the amplifier **11** and control tube **19** possessing a characteristic of the type shown in Fig. 2, it is possible to secure the reproducer volume-tuning dial setting relation shown in Fig. 3. This follows in view of the requirement that the tube **19** holds its input substantially constant. Therefore, it automatically varies the signal strength at the input to the amplifier **9** in a manner inverse to the ordinates of the curve of Fig. 2.

In order to secure the resonance characteristics shown in Fig. 2 it is necessary that the resistance in the primary and secondary circuits of transformer **16** be kept as low as possible. One particular method of minimizing the amount of resistance in the transformer **16** without changing the amount of inductance is to employ a core of magnetite around which the coils **15** and **16** are wound. It has been found that such a transformer construction has a minimum of resistance, and will facilitate the design of the coupling network between the tube **11** and the tube **19** so as to secure the resonance curve shown in Fig. 2.

It is to be clearly understood that the coupling network between the amplifier **11** and the control tube **19** shown in Fig. 1 is not the only method of securing the resonance curve of Fig. 2. For example, in Fig. 4 there is shown a modified coupling network wherein the strapped grid and anode of the tube **19** is coupled to the high potential side of the primary coil **15** by a coupling condenser **15'**. An absorption circuit comprising a coil **16'** having a condenser **33'** connected in shunt thereto, is coupled to the coil **15** in such a manner that the resonance curve shown in Fig. 2 is obtained. This type of circuit produces the desired resonance curve because the circuits **15**, **17** and **16'**, **33'** are resonant to the same frequency. Those skilled in the art will realize that the curve in Fig. 2 can be obtained in such a case.

In Fig. 5 there is shown still another modification to demonstrate that many types of coupling between tubes **11** and **19** are possible. In this modification the coil **15** has its high potential side coupled to the strapped grid and anode of tube **19** by the coupling condenser **15'**. A path, including an inductance **50** connected in series with a condenser **51**, is connected in shunt with the coil **15**, and a condenser **52** is connected in shunt with the path including inductance **50** and condenser **51**. This coupling arrangement functions to produce the resonance curve of Fig. 2. When circuit **50**, **51** is made resonant to the desired operating frequency, the depression of the curve of Fig. 2 is obtained. The circuit including inductance **15** and condenser **52** is employed for fixing the off-resonance response of the curve.

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

What I claim is:

1. In combination, with a radio receiver comprising a radio frequency amplifier, a detector having a tuned input circuit and a reproducer, a gain control tube coupled with the detector input circuit and the amplifier to maintain uniform the signal carrier level at the detector input circuit in spite of variations in the signal carrier level impressed on the amplifier, and means including at least two overcoupled resonant circuits for coupling the gain control tube to the detector input circuit in such a manner that the coupling network has a double peaked resonance curve characteristic.

2. In combination, with a radio receiver comprising a radio frequency amplifier, a detector and a reproducer, a gain control tube coupled with the detector input and the amplifier output to maintain uniform the carrier level at the detector in spite of variations in the signal carrier level impressed on the amplifier, means for coupling the gain control tube to the detector input in such a manner that the coupling has a pronounced double peaked resonance curve characteristic, the coupling connection between said detector input and said gain control tube including an amplifier having its input coupled to the radio frequency amplifier output and its output coupled to the gain control tube input.

3. In combination with a superheterodyne receiver including a radio frequency amplifier, a frequency changer circuit arranged to produce a desired intermediate frequency, an intermediate frequency amplifier and a second detector, an automatic volume control network comprising an amplifier having its input coupled to a point between said frequency changer and said intermediate frequency amplifier, a gain control tube coupled to the output of said network amplifier, the gain control tube being connected to said radio frequency amplifier, frequency changer and intermediate frequency amplifier for controlling the gain thereof to maintain the input to the second detector at a substantially constant energy level, the value of the coefficient of coupling between the amplifier and the gain control tube of said volume control network being such that

the resonance curve of the input of the gain control tube has a double peak.

4. In combination with a superheterodyne receiver including a radio frequency amplifier, a frequency changer circuit arranged to produce a desired intermediate frequency, an intermediate frequency amplifier and a second detector, an automatic volume control network comprising an amplifier having its input coupled to a point between said frequency changer and said intermediate frequency amplifier, a gain control tube coupled to the output of said network amplifier, the gain control tube being connected to said radio frequency amplifier, frequency changer and intermediate frequency amplifier for controlling the gain thereof to maintain the input to the second detector at a substantially constant energy level, and means for overcoupling the amplifier and the gain control tube of said volume control network whereby the resonance curve of the input of the gain control tube has a double peak.

5. In combination with a superheterodyne receiver including a radio frequency amplifier, a frequency changer circuit arranged to produce a desired intermediate frequency, an intermediate frequency amplifier and a second detector, an automatic volume control network comprising an amplifier having its input coupled to a point between said frequency changer and said intermediate frequency amplifier, a gain control tube coupled to the output of said network amplifier, the gain control tube being connected to said radio frequency amplifier, frequency changer and intermediate frequency amplifier for controlling the gain thereof to maintain the input to the second detector at a substantially constant energy level, the value of the coefficient of coupling between the amplifier and the gain control tube of said volume control network being such that the resonance curve of the input of the gain control tube has a double peak, said gain control tube being of the diode rectifier type and having its anode coupled to the high potential side of the output of the volume control network amplifier.

6. A radio receiver comprising a high frequency amplifier having a resonant input network tuned to a desired signal carrier frequency, a rectifier provided with a cathode and at least one cold electrode, means for coupling said cold electrode to said network, a direct current connection between said electrode and a gain control electrode of the amplifier, said coupling means including a resonant network tuned to said frequency, the resonance curve characteristic of the coupling means having a pair of frequency peaks each spaced from said carrier frequency.

7. A radio receiver comprising a high frequency amplifier having a resonant input network tuned to a desired signal carrier frequency, a rectifier provided with a cathode and at least one cold electrode, means for coupling said cold electrode to said network, a direct current connection between said electrode and a gain control electrode of the amplifier, said coupling means including a resonant network tuned to said frequency, the resonance curve characteristic of the coupling means having a pair of frequency peaks each spaced 5 kilocycles from said carrier frequency.

8. A radio receiver comprising a high frequency amplifier having a resonant input network tuned to a desired signal carrier frequency, a rectifier provided with a cathode and at least one cold electrode, means for coupling said cold electrode to the high potential side of said network, a direct current connection between said electrode and a gain control electrode of the amplifier, said coupling means including a resonant network tuned to said frequency, the resonance curve characteristic of the coupling means having a pair of frequency peaks each spaced from said carrier frequency.

9. In a radio receiver of the type including a signal transmission tube, a demodulator following the tube, a coupling network between the tube and demodulator, the network having substantiallly a single peaked resonance curve characteristic, an automatic volume control arrangement for the receiver comprising a rectifier having an output connection to said tube, a signal coupling network, including at least two coupled resonant circuits, between the rectifier and the output of said tube, said second network having a double peaked resonance curve characteristic with a substantial depression between the peaks.

10. In a radio receiver of the type including a signal transmission tube, a demodulator following the tube, a coupling network between the tube and demodulator, the network having substantially a single peaked resonance curve characteristic, an automatic volume control arrangement for the receiver comprising a rectifier having an output connection to said tube, a signal coupling network, comprising a transformer having its primary and secondary windings overcoupled, between the rectifier and the output of said tube, said second network having a double peaked resonance curve characteristic with a substantial depression between the peaks.

11. In a radio receiver of the type including a signal transmission tube, a demodulator following the tube, a coupling network between the tube and demodulator, the network having substantially a single peaked resonance curve characteristic, an automatic volume control arrangement for the receiver comprising a rectifier having an output connection to said tube, a signal coupling network between the rectifier and the output of said tube, said second network having a double peaked resonance curve characteristic with a substantial depression between the peaks, the second network comprising a tuned circuit coupled to the rectifier, and a tuned absorption circuit coupled solely to the tuned circuit.

12. In a radio receiver of the type including a signal transmission tube, a demodulator following the tube, a coupling network between the tube and demodulator, the network having substantially a single peaked resonance curve characteristic, an automatic volume control arrangement for the receiver comprising a rectifier having an output connection to said tube, a signal coupling network between the rectifier and the output of said tube, said second network having a double peaked resonance curve characteristic with a substantial depression between the peaks, the second network comprising a series resonant circuit, and an anti-resonant circuit whose reactive elements are in shunt with the series circuit.

13. In a radio receiver of the type including a signal transmission tube, a demodulator following the tube, a coupling network between the tube and demodulator, the network having substantially a single peaked resonance curve characteristic, an automatic volume control arrangement for the receiver comprising a rectifier having an output connection to said tube, a signal coupling network, including at least two coupled resonant circuits, between the rectifier and the

output of said tube, said second network having a double peaked resonance curve characteristic with a substantial depression between the peaks, and said single peaked characteristic being substantially broad.

14. In a receiver which includes a signal amplifier, a detector, and a reproducer following it, the detector having a tuned input network, an automatic volume control arrangement for the receiver including a diode rectifier, the diode anode being connected to a gain control electrode of the amplifier, and a signal coupling network between the diode electrodes and the tuned input network, the coupling network having a resonance curve characteristic with a substantial depression at the received carrier frequency and a pair of spaced peaks at the extremities of the modulation side bands whereby the reproducer volume-tuning characteristic of the receiver has a peak at the carrier.

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