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G. L. BEERS

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AUTOMATIC SELECTIVE FADING CONTROL CIRCUIT

Filed Dec. 18, 1936

2 Sheets-Sheet 1

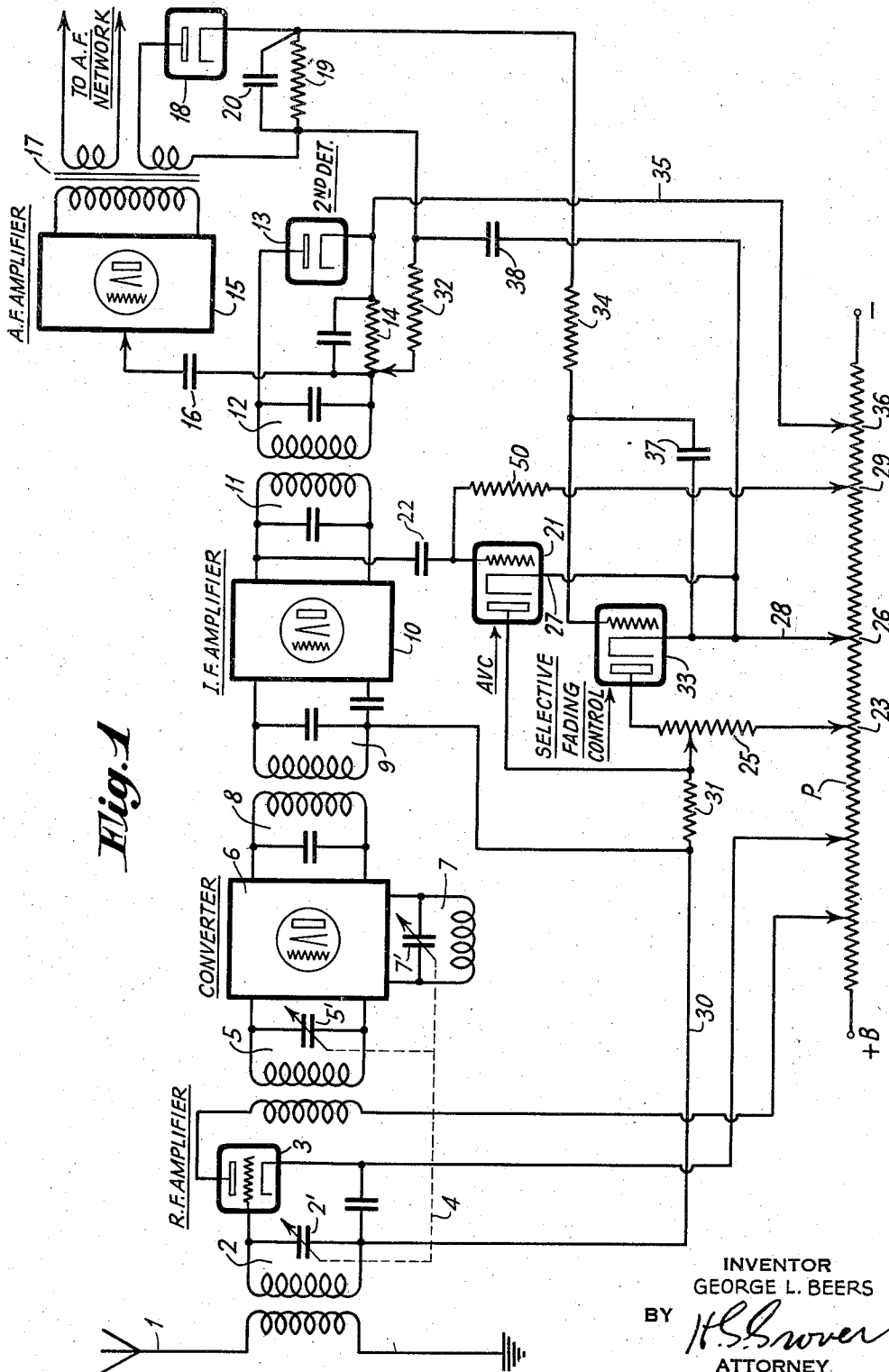


Fig. 1

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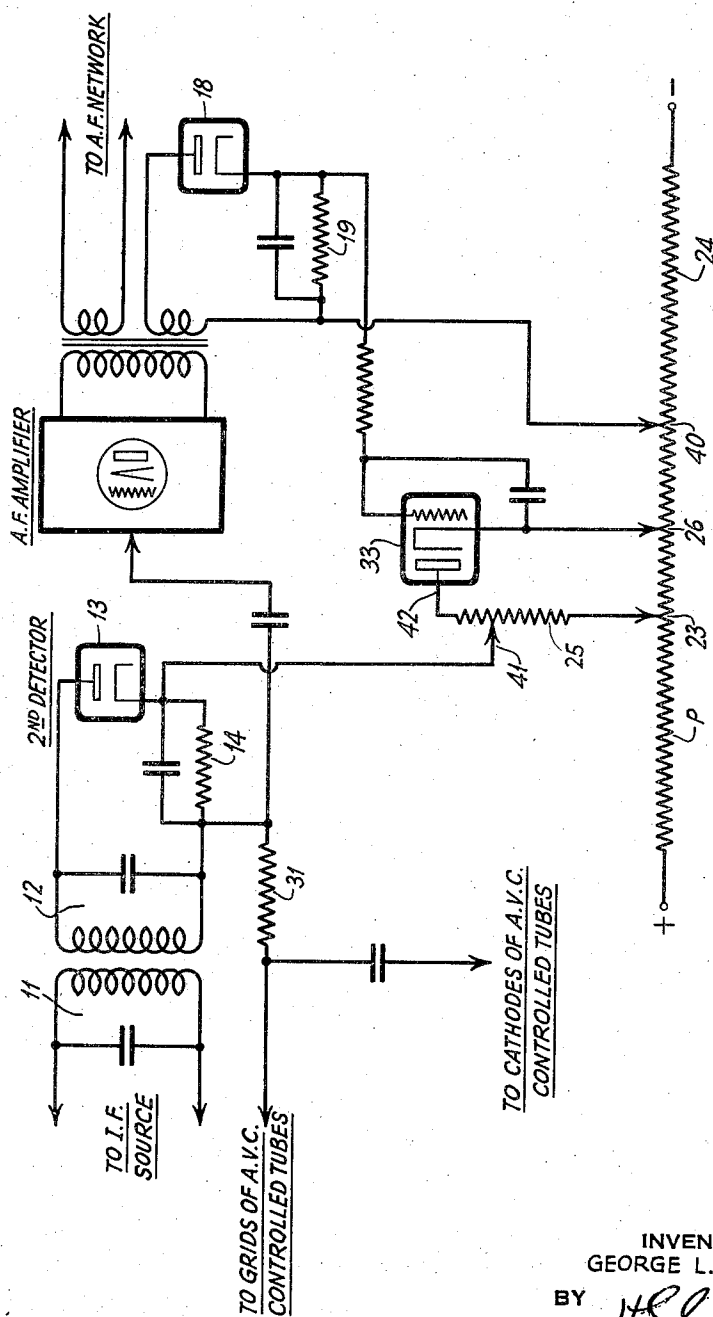
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2 Sheets-Sheet 2

Fig. 2



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AUTOMATIC SELECTIVE FADING CONTROL
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6 Claims. (Cl. 250—20)

My present invention relates to automatic gain control circuits for radio signalling systems, and more particularly to a control circuit which is intended to compensate for some of the disagreeable effects which are encountered when receiving signals subject to selective fading.

When utilizing a conventional radio receiver equipped with automatic volume control to compensate for normal carrier fading effects, selective fading phenomena produce disagreeable effects in the reproduced signals. One of the most disagreeable effects which selective fading produces in such a receiver arises from the fact that the audio output becomes several times normal. This arises by virtue of the fact that when a carrier wave fades out during the selective fading cycle the percentage modulation of the received signal is greatly increased, and the automatic volume control network (hereinafter termed AVC) endeavors to maintain a constant carrier amplitude at the second detector.

It may be stated, therefore, that it is one of the main objects of my present invention to provide a receiver which is equipped with an AVC network, and, in addition, a gain control system which functions to reduce the sensitivity of the receiver when the carrier wave fades out during a selective fading period thereby preventing the audio output from becoming several times normal.

Another important object of the invention is to provide an automatic volume control circuit for a radio receiver, and which circuit automatically reduces the gain of the radio frequency transmission tubes as the received carrier increases in amplitude; and an additional gain control arrangement being provided for reducing the gain of the radio frequency or audio frequency, transmission tubes when the percentage modulation of a received signal substantially exceeds 100 per cent modulation whereby the sensitivity of the receiver is automatically limited if selective fading causes the percentage modulation of the received signal to exceed 100 per cent.

Another object of the invention is to provide a radio receiver with a radio frequency transmission tube and a demodulator, means being included which is responsive to carrier amplitude increase at the demodulator input for reducing the gain of the radio frequency transmission tube as long as the percentage modulation of a received signal is less than 100 per cent; additional means being provided for deriving from the audio output of the demodulator a potential which is employed to decrease the gain of a radio fre-

quency, or an audio frequency, transmission tube when the received signal modulation exceeds 100 per cent.

Still other objects of the invention are generally to improve the efficiency of receivers equipped with automatic volume control, and more especially to provide an AVC receiver which is not only reliable in operation, but is 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 drawings, in which I have indicated diagrammatically two circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 diagrammatically shows a circuit embodying the invention,

Fig. 2 shows a modification.

Referring now to the accompanying drawings, wherein like reference characters in the two figures designate similar circuit elements, the receiving system shown is of the well known superheterodyne type. In general, such a receiver comprises a signal collector 1 which is constructed to feed signals to the tunable input circuit 2 of the radio frequency amplifier 3. The numeral 2' denotes the usual variable tuning condenser for the amplifier input circuit, and it will be understood that as many stages of tunable radio amplification as is desired may be provided. The signal collector 1 may be of the grounded antenna type, but it may, also, be the usual antenna employed by an automobile receiver, and it may even comprise a radio frequency distribution line. The amplified radio frequency signals, which signals may be in the broadcast band of 500 to 1500 k. c. (or in the short wave range when the receiver is of the all-wave type), are impressed upon the tunable input circuit 5 of the converter network. The converter 6 may be of the composite local oscillator-first detector type, as, for example, one using a 6A7 pentagrid converter tube.

On the other hand, and if desired, it may employ separate local oscillator and first detector tubes. The numeral 7 denotes the tunable local oscillator circuit, and the numerals 5' and 7' designate the variable tuning condensers of circuits 5 and 7 respectively. The rotors of the tuning condensers 2', 5' and 7' may be arranged in the usual manner for mechanical uni-control ad-

justment, and the dotted line 4 denotes such mechanical uni-control means. Those skilled in the art are fully acquainted with the circuit arrangements used in the converter network, and it is believed sufficient for the purposes of this application to point out that in the output circuit 8 there is produced energy of a desired operating I. F., and the latter may be chosen from a range of 75 to 500 k. c.

10 The I. F. energy is impressed upon the input circuit 9, fixedly tuned to the operating I. F., which functions as the input circuit of the I. F. amplifier 10. The output circuit 11 of the amplifier 10 is tuned to the operating I. F., and it is in turn reactively coupled to the I. F. tuned input circuit 12 of the second detector 13. It is to be understood that the amplifier 10 may comprise several stages of amplification if desired; and while the detector 13 has been shown as of the diode type, any other type of tube may be used. The audio component of the rectified I. F. current flowing through load resistor 14, the latter being shunted by an I. F. bypass condenser, is impressed upon an audio frequency amplifier 15 through a path including the audio coupling condenser 16. The audio amplifier 15 may comprise one, or more, stage of amplification, and the amplifier output is impressed upon an audio utilization network by means of the audio coupling transformer 17. A part of the audio frequency voltage is impressed upon a diode 18, the anode of the latter being connected to its cathode through a load resistor 19 which is shunted by bypass condenser 20. It is to be understood that the audio voltage for diode 18 may be taken off from the audio system at any point between the second detector 13 and the final utilizing device; the latter may be a reproducer of any desired type.

40 The AVC network of the receiver comprises an electron discharge tube 21 which has its input grid reactively coupled, as through a condenser 22, to the I. F. output circuit of the I. F. amplifier 10. The plate of tube 21 is connected to the point 23 on the common direct current voltage supply bleeder resistor P. It is to be understood that the resistor P is the usual voltage supply resistor, and is fed with direct current derived from the power supply circuit of the radio receiver. The connection to point 23 includes the resistor 25, the cathode of tube 21 being connected to point 26 of bleeder resistor P through a path which includes lead 27 and lead 28; the control grid of tube 21 is connected through resistor 50 to point 29 on the voltage supply resistor P. It will be observed that the voltage points 23, 26 and 29 are all respectively of a decreasing positive potential.

The potential difference between points 26 and 29 is such that the tube 21 functions as a rectifier of the I. F. energy impressed on the grid of tube 21, and the direct current voltage developed across resistor 25 is employed as the AVC bias. The low alternating potential terminals of the radio frequency amplifier, and I. F. amplifier, grid circuits are connected by connection 30 to the anode side of resistor 25. The numeral 31 denotes a filter resistor inserted in the AVC network to suppress pulsating components in the AVC bias. Those skilled in the art know that the function of the AVC network is to maintain the carrier amplitude at the detector input circuit 12 substantially uniform in spite of a wide range of carrier amplitude variation at the signal collector 1. As the received carrier ampli-

tude increases the direct current voltage developed across resistor 25 increases, and this voltage is applied in a negative biasing sense to the signal grids of the controlled tubes; with the result that the gain of each of the latter is reduced thereby tending to maintain the carrier amplitude substantially uniform at the detector input circuit 12.

As pointed out heretofore, one of the most disagreeable effects which selective fading produces in a receiver of the type described to this point, is that due to the audio output becoming several times normal. Since when a carrier wave fades out during the selective fading cycle, the percentage modulation of the received signal is greatly increased, and since the AVC tends to maintain a constant carrier level at the detector, the audio output is correspondingly increased. This follows from the fact that the controlled tubes normally, in the absence of received signals, have a bias such that the tubes are operated with maximum amplification. Since the AVC bias is derived from the rectified signal carrier, it follows that in selective fading the AVC bias decreases, and the amplification of the controlled tubes necessarily rises. It is, of course, understood that in selective fading the carrier fades with respect to its side bands.

To overcome this increase in receiver sensitivity during the selective fading cycle, the diode 18 is provided for rectification of the audio voltage produced by the detector 13. The diode anode side of load resistor 14 is connected to the anode side of resistor 19 through a path which includes an adjustable tap in series with resistor 32. The cathode side of resistor 19 is connected by a lead, including a resistor 34, to the control grid of an electron discharge tube 33. The plate of tube 33 is connected to the direct current voltage point 23 through the AVC resistor 25, the cathode of tube 33 being connected by lead 28 to point 26. The cathode of the second detector 13 is connected by lead 35 to the voltage point 36 on resistor P, point 36 being at a negative potential with respect to point 29.

A condenser 37 is connected between the cathode of tube 33 and the grid side of resistor 34, and a condenser 38 is connected between the junction point of resistors 32 and 19, and the cathode of tube 33. The plate of the radio frequency amplifier 3 is connected to the plus B side of the supply resistor 24, the cathode of the amplifier being connected to a point which is of less positive potential; and the signal grid of the amplifier 3 returns to the still less positive potential point 23 through the AVC connection 30 and resistor 25. The tube 33 has been designated as the "selective fading control", since the space current flow thereof is directed through resistor 25 for the production of the sensitivity reduction bias when the selective fading occurs.

The direct current potential which is developed across resistor 14 is directly proportional to the amplitude of the carrier wave applied to input circuit 12. If desired, the diode 13 may be a separate diode which is independent of the second detector. The diode 18 develops a direct current potential across resistor 19 which is proportional to the peaks of the audio potentials impressed upon diode 18. The load resistors 14 and 19 are connected in series. The tube 33, which may be of the pentode type if desired, is so connected that its grid potential is determined by the difference in the direct current potentials derived from the diodes 13 and 18. The tube 33 is provided

with a fixed negative bias which is sufficient to reduce its plate current substantially to the cut-off value when no signals are impressed on the diodes 13 and 18. This fixed-cut off bias is equal to the potential drop between the points 26 and 36 of bleeder resistor P.

The direct current potential developed across resistor 19 causes the grid of tube 33 to become more positive, whereas the direct current potential developed across resistor 14 causes the grid to become more negative. This will be clear when it is realized that the grid of tube 33 is connected to the cathode side of resistor 19, whereas it is connected to the anode side of resistor 14. The circuit constants of the system are so adjusted that the direct current potentials developed across resistors 14 and 19 are equal when the percentage modulation of a received signal is slightly over 100 per cent. If the percentage modulation exceeds this value then a greater potential is developed across the output resistor 19 of rectifier 18 than across the load resistor 14, and the grid of tube 33 will then become more positive. This causes plate current to flow through the resistor 25, since the positive potential causes the grid of tube 33 to become more positive with respect to its cathode. Hence, it will be seen that the negative bias on the controlled tubes is increased, when the direct current potential across resistor 19 exceeds that developed across resistor 14.

In this way the sensitivity of the receiver is automatically limited when the percentage modulation of a received signal increases in excess of 100 percent, as is the case during periods of selective fading. Tube 21 is the conventional type of AVC tube, and, as noted before, it functions to develop the AVC bias across resistor 25. As long as the percentage modulation of a received signal remains below 100 per cent, the potential developed across resistor 14 is greater than that obtained across resistor 19; and the grid of tube 33 remains at a more negative potential than that required for plate current cut-off. Under this condition the AVC system functions in the normal manner. Therefore, it will be appreciated that there has been provided in the receiving system shown in Fig. 1 a pair of automatic control circuits for the gain regulation of the radio frequency transmission network; one of the controls operating to reduce the gain of the radio transmission network as the signal carrier amplitude increases but the signals have less than 100 per cent modulation; and the other gain control system being responsive to an increase in the percentage modulation substantially above 100 per cent for the purpose of reducing the gain of the radio frequency transmission network.

In addition to the beneficial results obtained from the above invention during cycles of selective fading, there is also obtained a certain degree of noise suppression when tuning between stations. This follows from the fact that unless a carrier wave is present the potential as developed by the rectifier 18 will be greater than that developed by the diode 13. As a result of this action the sensitivity of the receiver will be such as to keep the noise output at a relatively low value.

In Fig. 2 there is shown a modification of the invention wherein the tube 21 of Fig. 1 is dispensed with. In place of the tube 21 the second detector diode 13 is used to supply the normal AVC bias. The diode output resistor 14 is connected in series with the load resistor 25 of the

"selective fading control" tube 33. The resistor 25 is connected to the point 23 on the voltage divider resistor P. The anode end of diode output resistor 19 is connected to the point 40 on resistor P. The point 40 is sufficiently negative with respect to the point 26, to which the cathode of tube 33 is connected, to bias tube 33 beyond the point of plate current cut-off by an amount equal to, or slightly greater than, the potential developed across resistor 14 when a signal is being received. It will be observed that the drop across a portion of the voltage divider resistor P is used to supply the negative potential equivalent to the carrier amplitude, which in the system illustrated in Fig. 1 was developed across resistor 14 and which must be exceeded by the positive potential developed across resistor 19 before plate current is caused to flow through resistor 25.

Since resistors 14 and 25 are connected in series, the AVC bias and the "selective fading control" bias are both applied to the grids of the controlled tubes. It is, of course, clear that the potential developed across resistor 25 causes the grids of the controlled tubes to assume a more negative potential than that determined by the normal AVC bias. Thus, when the percentage modulation of a received signal exceeds 100%, as is the case during selective fading cycles, the audio output of the receiver will not increase, but can be caused to decrease. The degree of reduction in audio output in either of the arrangements shown in Fig. 1 or Fig. 2 can be varied, for example by utilizing any desired portion of the voltage developed across resistor 25.

The potential developed across resistor 25 may be used to control a tube, or tubes, other than those controlled by the normal AVC system. For example, in Fig. 2 the anode 42 of tube 33 can be connected to the low potential end of the grid circuit of an I. F. tube. This I. F. tube may be located in the circuit between a point in the I. F. amplifier from which the AVC control potential is derived and the second detector. If desired, the contact 41 may be moved to the point 23, and the AVC and "selective fading control" systems will then function independently. The "selective fading control" potential may also be applied to an audio frequency amplifier tube. In this case the low potential end of the grid circuit of the A. F. tube is likewise connected to the anode 42 of tube 33. In some cases it is desirable that the controlled A. F. tube be connected in the audio system after the point to which the diode 18 is connected.

The AVC system used in the arrangement illustrated by Fig. 2 should be such that the audio output, as determined by the normal AVC will remain substantially constant regardless of the strength of the signal being received. If the audio output varies greatly with signal strength, then the percentage modulation at which the "selective fading control" will operate will vary with the strength of the received signal, since the potential developed across resistor 19 is compared to a fixed potential, representing the carrier amplitude, the said potential being derived from the voltage divider. The system illustrated in Fig. 1 automatically compensates for any lack of effectiveness in the AVC, since the voltage developed across resistor 19 is compared to that which appears across resistor 14. Thus, if the audio output of the receiver and the voltage across resistor 19 increases due to any deficiency of the normal AVC, the voltage across resistor 14 must correspondingly increase. This renders the "se-

lective fading control" system independent of the strength of the received signal, and dependent only on the percentage modulation of the said signal.

- 5 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
10 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 receiving system or the type which includes a modulated carrier wave amplifier followed by a detector, means deriving a direct current voltage from the carrier energy and which voltage varies directly with carrier amplitude, a second means for deriving a direct current voltage
20 from the modulation component of the detected signals, a third means for combining said two voltages in polarity opposition and in such a manner that the magnitude of the combined voltage is substantially zero at 100 per cent modulation of the modulated carrier wave, and an additional means, responsive to a departure in polarity and magnitude of said combined voltage
25 from said zero value, for automatically reducing the gain of said carrier amplifier.

- 30 2. In a radio receiver provided with a modulated carrier wave amplifier, a detector including a load resistor for developing a direct current voltage from the received carrier current, a rectifier including a load resistor for developing a
35 direct current voltage from the modulation current of the detected carrier energy, an electron discharge tube having an impedance in its space current path, means biasing said tube to cut-off, means connecting said two direct current voltages
40 in polarity opposition and impressing the resultant voltage upon the input electrodes of said tube, and connections for impressing the voltage drop across said impedance upon the amplifier as a gain control voltage.

- 45 3. In a radio receiver provided with a modulated carrier wave amplifier, a detector including a load resistor for developing a direct current voltage from the received carrier current, a rectifier including a load resistor for developing a
50 direct current voltage from the modulation current of the detected carrier energy, an electron discharge tube having an impedance in its space current path, means connecting said two direct current voltages in polarity opposition and impressing the resultant voltage upon the input
55 electrodes of said tube, connections for impressing the voltage drop across said impedance upon the amplifier as a gain control voltage, and a second rectifier having a carrier input connection
60 to said amplifier output, said impedance being included in the space current path of said second rectifier.

4. In a radio receiver provided with a modulated carrier wave amplifier, a detector including
65 a load resistor for developing a direct current

voltage from the received carrier current, a rectifier including a load resistor for developing a direct current voltage from the modulation current of the detected carrier energy, an electron discharge tube having an impedance in its space
5 current path, means connecting said two direct current voltages in polarity opposition and impressing the resultant voltage upon the input electrodes of said tube, connections for impressing the voltage drop across said impedance upon
10 the amplifier as a gain control voltage, a second rectifier having an input circuit coupled to the amplifier output circuit, said second rectifier including a load resistor for developing a direct current voltage from the amplified signals, the
15 voltage drop across the last resistor being in polarity opposition when applied to said amplifier as regards the voltage drop across the first resistor.

5. In a receiving system of the type employing
20 a detector preceded by a radio frequency signal transmission tube and followed by an audio frequency utilization network, an automatic volume control network for automatically reducing the transmission efficiency through said radio trans-
25 mission network as the received modulated carrier amplitude increases, means for overcoming the effect of selective fading caused by fading of the carrier with respect to its modulation side bands, said last means comprising a device for
30 deriving a direct current voltage from the carrier energy, a second device for deriving a direct current voltage from the modulation current of the detected carrier energy, means combining the last
35 two voltages in polarity opposition, and an additional device, responsive to the resultant of the combined voltages, for automatically reducing the transmission efficiency of the signals to the detector when the selective fading occurs to an extent such that the effective percentage modulation
40 of the signals is in excess of 100 per cent.

6. In a receiving system of the type employing a detector preceded by a radio frequency signal transmission tube and followed by an audio frequency utilization network, an automatic volume
45 control network for automatically reducing the transmission efficiency through said receiver as the received modulated carrier amplitude increases, means for overcoming the effect of selective fading caused by the fading of the carrier
50 with respect to its modulation side bands, said last means comprising a device for deriving a direct current voltage from the modulation current of the detected carrier energy, means providing a second direct current voltage which is
55 related in magnitude to a desired carrier amplitude, means combining the two direct current voltages in polarity opposition, and an additional device, responsive to the resultant of the combined voltages, for automatically reducing the transmission efficiency of the receiver when the selective fading occurs to an extent such that the effective percentage modulation of the signals is excessive.

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