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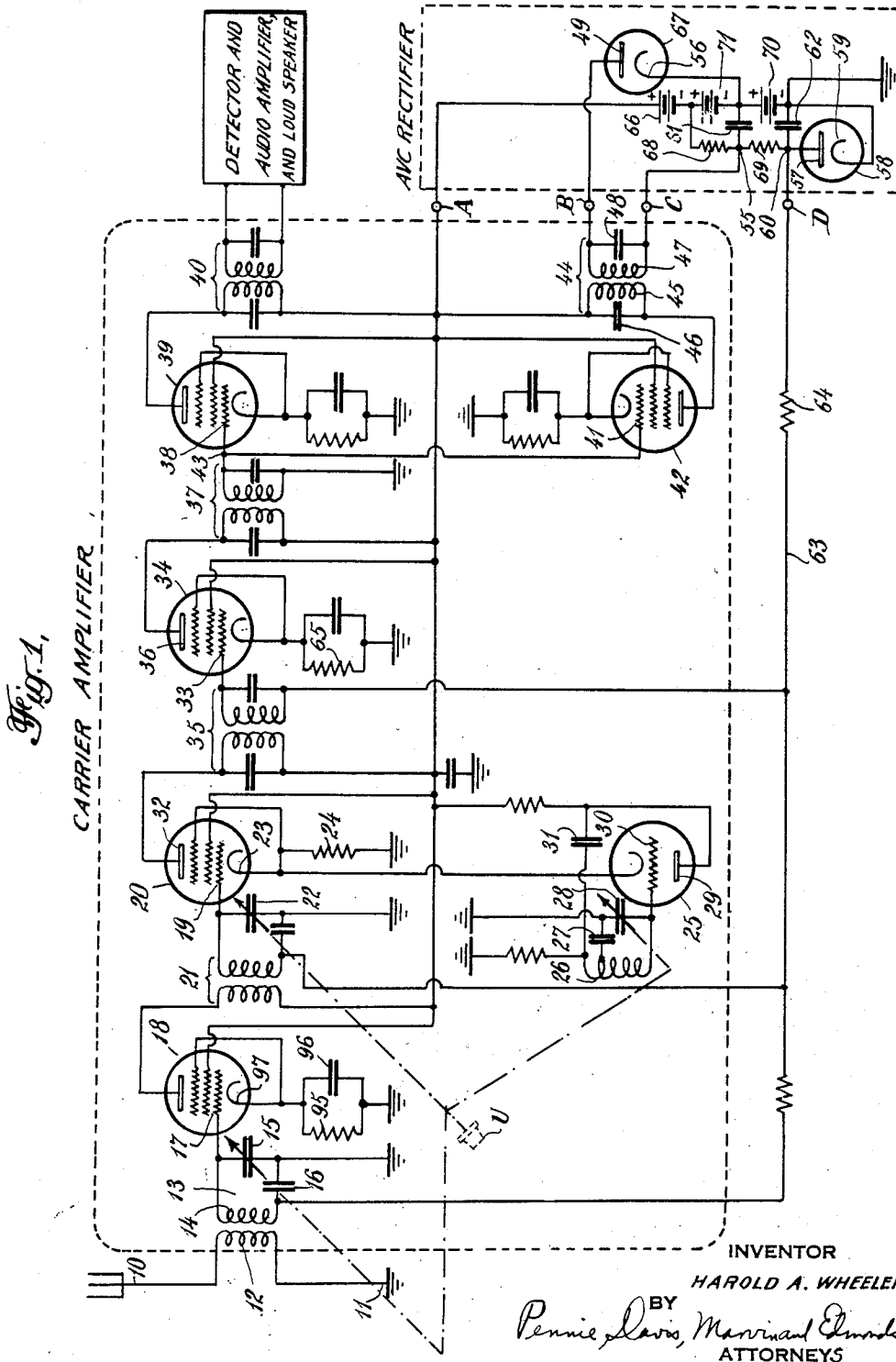
H. A. WHEELER

2,073,038

RADIO RECEIVING SYSTEM

Filed March 9, 1934

2 Sheets-Sheet 1



March 9, 1937.

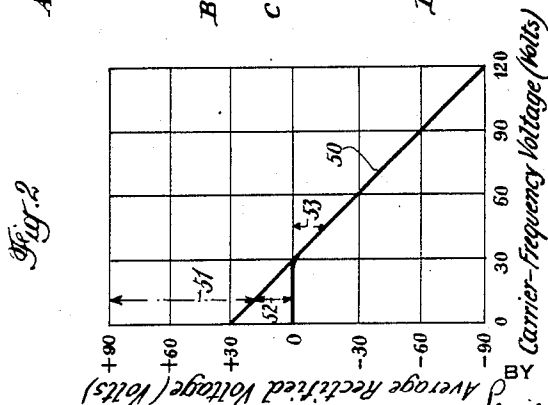
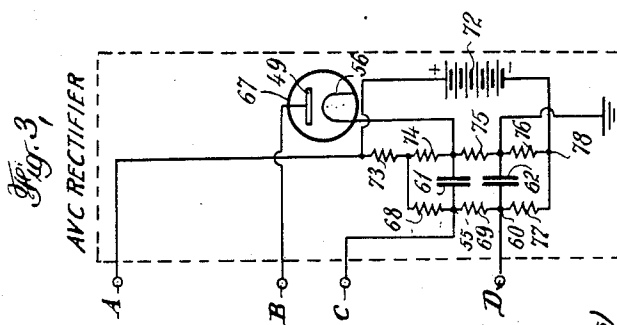
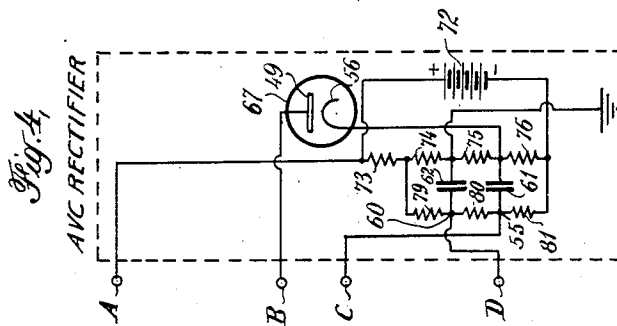
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RADIO RECEIVING SYSTEM

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2 Sheets-Sheet 2



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2,073,038

RADIO RECEIVING SYSTEM

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Application March 9, 1934, Serial No. 714,784

20 Claims. (Cl. 250—20)

This invention relates to automatic control of amplification in amplifiers and repeaters, and more particularly to the control of repeaters utilized in carrier-frequency signaling systems, to maintain the signal of such repeaters more uniform than the signal input, over a wide range of received signal voltage.

This application is a continuation-in-part of my copending application Serial No. 691,927, filed October 3, 1933, Patent No. 2,050,679, August 11, 1936, the arrangement shown in Fig. 1 of the present application being partly included in Fig. 4 of my said copending application, and Fig. 2 of the present application being substantially like Fig. 12 of my said copending application.

In my United States Letters Patent Nos. 1,879,861, 1,879,862 and 1,879,863, there are shown systems for automatically controlling the amplification in amplifiers. In the arrangements of these patents, the amplifier output is impressed on a rectifier which develops in response thereto a uni-directional voltage which varies with the signal input intensity. This uni-directional voltage is impressed on a control electrode of each of one or more of the amplifier tubes, to automatically vary the amplification therein inversely with variations of the signal input voltage, thereby maintaining the amplified signal output voltage variation much less than the received signal input voltage variation. In the arrangements of these patents, means are provided for maintaining an output electrode of the rectifier normally slightly negative relative to the cathode of the controlled amplifier, an increase in the signal input then causing the said output electrode, and therefore the amplifier control electrode, to become more negative. Maintaining the rectifier output electrode normally slightly negative relative to the cathode of the controlled amplifier permits the use of a single common source of direct voltage for all tubes in the system, because it avoids the necessity for a bias voltage to be inserted in the connection between the said output electrode and the said control electrode.

In my said copending application, Serial No. 691,927, there is shown a system of "suspended" automatic volume control in which the control operates only when the received signal input exceeds a predetermined threshold intensity. This system also is arranged so that only a single common source of direct voltage need be used to supply polarizing voltages to all vacuum tubes. In this system, the direct voltage source is connected across a high resistor, and normally causes a direct current to flow through the resistor.

The expression "normally" as used in this specification means in the absence of a signal.

A connection is made to a control electrode of the controlled amplifier from a point on this resistor. In the absence of a signal, this point is slightly negative relative to the cathode of the controlled amplifier. The automatic control of amplification in this amplifier is effected by the connection of a rectifier, responsive to the output of this amplifier, between an intermediate point on the voltage source and an intermediate point on the high resistor. The rectified current through the resistor causes a negative change of voltage at both said points thereon, as the signal input exceeds the threshold value. The expression "negative change of voltage" as used in this specification signifies that the voltage becomes more negative or less positive relative to ground.

According to the present invention, there is employed an arrangement similar in certain respects to that of my said application, Serial No. 691,927. The similarity resides largely in the provision of a high resistor normally carrying direct current from a direct voltage source, and in the provision of a rectifier responsive to the output of the controlled amplifier, connected between an intermediate point on the high resistor and an intermediate point on the voltage source. The resistor may be arranged, if desired, so that the automatic volume control operates to some extent on all values of received signal voltage, instead of being "suspended" as in the arrangement of the said application, Serial No. 691,927. The rectifier is preferably of the diode type, although a different type of rectifier, such as a triode, may be employed, if desired. The arrangements according to this invention are such that the space current and polarizing voltages for all the vacuum tubes in the system can be supplied from a single common source of operating voltage. The direct-voltage source associated with the resistor may be a relatively low-resistance voltage divider supplied with direct voltage from a unitary source.

According to one embodiment of the invention, the rectifier electrodes are normally maintained substantially negative relative to the cathode of the controlled amplifier, more negative than in the case of my above-mentioned patents 1,879,861 and 1,879,863. According to another embodiment, the rectifier electrodes are normally maintained considerably positive relative to the cathode of the controlled amplifier, as in the case of the said application, Serial No. 691,927.

The above and other features of the invention

are apparent from the following detailed description and from the accompanying drawings, of which:

Fig. 1 shows an embodiment of the invention employing a "suspender" diode, which provides "suspended" automatic volume control as shown in Fig. 4 of the said application, Serial No. 691,927;

Fig. 2 shows graphically the change of automatic-volume-control bias voltage with change of carrier output voltage, in the circuit of Fig. 1;

Fig. 3 shows an "Avc rectifier" section which may be substituted for the corresponding section in Fig. 1; and

Fig. 4 shows another "Avc rectifier" section which may be substituted for the corresponding section in Fig. 1.

Fig. 1 shows a complete superheterodyne radio receiver including a system of automatic volume control according to this invention. The carrier amplifier, for amplifying the signals at carrier frequencies, is shown in detail. Signals are collected by an antenna 10 connected to ground 11 through an antenna primary coil 12. A tunable radio-frequency selecting circuit 13, comprising a secondary coil 14, a variable condenser 15, and a fixed condenser 16, is coupled to the antenna-ground circuit by mutual inductance between coils 12 and 14. The lower side of variable condenser 15 is grounded. The control grid, or control electrode, 17 of a repeating, or amplifying, vacuum tube 18 is connected to the upper side of coil 14; and the input circuit of tube 18 is completed by the connection of a cathode bias resistor 19, shunted by a radio-frequency bypass condenser 20 between the cathode 21 and ground.

The output circuit of tube 18 is coupled to the control grid 19 of a pentode modulator tube 20 through a radio-frequency coupling system comprising a transformer 21 and a variable condenser 22 for tuning the secondary of the transformer. One side of the variable condenser 22 is connected to the grid 19, and the other side of the condenser is connected to ground. From ground, the input circuit of the modulator tube is completed to the cathode 23 through a bias resistor 24.

A locally generated radio-frequency voltage is applied to the modulator by means of a tunable oscillator comprising oscillator tube 25 and its associated circuits. The tunable oscillator circuit comprises a coil 26, a fixed condenser 27 and a variable condenser 28. Oscillations are caused by the feedback circuit between the anode 29 and the grid 30 of the tube, connected through condenser 31 and the tunable oscillator circuit. The oscillator produces a radio-frequency voltage across the resistor 24 which is in the cathode lead of the oscillator tube. Since this resistor is also in the cathode lead of the modulator tube 20, this voltage is impressed on the input circuit of the modulator and therefore serves to modulate the signal.

Modulation takes place in the manner of superheterodyne receivers, well known in the art, wherefore there appear in the output circuit of the modulator, signals of a frequency equal to the difference between the radio signal frequency and the local oscillator frequency. This difference frequency, which is known as the intermediate frequency, is selectively coupled from the circuit of the modulator anode 32 to the control grid 33 of a first intermediate-frequency amplifier tube 34, through a double-tuned intermediate-frequency transformer 35, tuned to selectively pass this intermediate frequency.

To facilitate tuning the receiver to the frequencies of the various transmitting stations, the variable tuning condensers 15 and 22 associated with the radio-frequency transformers and the variable condenser 28 of the oscillator circuit are mechanically connected and operated by a single unicontrol device U, as indicated by the dot-dash lines. Condenser 28 is so adjusted relative to condensers 15 and 22 that the frequency difference remains substantially constant over the tuning range of frequency.

The output of amplifier 34 is selectively coupled from the circuit of anode 36 through a second double-tuned intermediate-frequency coupling system 37 to the input grid 38 of a second intermediate-frequency amplifier tube 39. The output of the second intermediate-frequency stage is selectively coupled through a third double-tuned intermediate-frequency coupling system 40 to subsequent apparatus of the receiver, indicated generally by the rectangle labelled "Detector and audio amplifier, and loudspeaker". This subsequent apparatus may be of any conventional type. No detailed description of this apparatus is required since it is well known in the art and constitutes no part of this invention.

The automatic volume control circuit, according to this invention, is associated and connected with the receiver in the following manner: The input grid 41 of an intermediate-frequency amplifier tube 42 is connected to the terminal 43 of the secondary coil of the tuned coupling system 37. By this connection, the intermediate-frequency output of amplifier tube 34 is also coupled to the tube 42. The anode circuit of tube 42 is connected to a broad-band double-tuned intermediate-frequency coupling system 44 of which the primary circuit composed of coil 45 and condenser 46 is inductively coupled to the secondary circuit composed of coil 47 and condenser 48.

The anode 49 of a rectifier 67 of the diode or any other suitable two-electrode type is connected at B to the upper terminal of coil 47. The circuit of the rectifier is completed between the output electrodes 49 and 56, through a bridge circuit, as follows: The bridge circuit is formed by arranging high resistors 68 and 69 in series with another diode 58 and with direct-voltage sources 70 and 71 the intermediate point 55 between these resistors being connected to the lower end of the secondary coil 47 (and thence to the output electrode 49), and the cathode 56 of diode 67 being connected to the intermediate point which is the junction of voltage sources 70 and 71. The lower terminal 60 of resistor 69 is connected to the anode 57 of diode 58, which is called a "suspender diode". The cathode 59 of suspender diode 58 is connected to the lower end of voltage source 70 and to ground. The diode 58 is a unidirectional conductor, but is not used as a rectifier.

In order to supply sufficient space voltage for the tubes of the receiver, the voltage due to sources 70 and 71 is augmented by an additional direct voltage source 66 in series therewith. The positive side of source 66 is connected to the anodes of all the tubes, as shown, and may also be connected to any or all of the tubes included in the "Detector and audio amplifier". The individual sources 66, 71 and 70 may be considered as a unitary source which is so connected that it can be used to supply all the space voltages and space current required by the tubes in the receiver. The positive side of this unitary source

is connected to the anodes of all the tubes shown, other than the diodes, and the negative side to the cathodes of the same tubes, through the ground connection. The path of resistors 68 and 69 and diode 58 is a high-resistance direct-current path between two different points on this unitary source; and points 55 and 60 are intermediate points in this path. By this arrangement of the voltage source, the normal voltage (substantially zero in the absence of a signal) is maintained between the electrodes 49 and 56.

Each of the diodes 67 and 58 has an internal resistance, when its anode is positive relative to its cathode, which is much lower than the value of either of the resistors 68 and 69. Each of these diodes is a unidirectional conductor, because, when its anode becomes negative relative to its cathode, the space current is substantially zero. Therefore, the anode 57, which is connected to point 60, is effectively grounded to cathode 59 when the junction 55 has a positive voltage relative to ground. In the absence of a signal, point 55 is maintained at a positive voltage by voltage sources 70 and 71, the resulting current flowing through resistors 68 and 69 and the diode 58. The current through these resistors in the absence of a signal is an auxiliary direct current. These resistors and voltage sources are so proportioned that the open circuit voltage at the intermediate point 55 is substantially the same as that at the intermediate point between sources 70 and 71. Consequently, the connection of the cathode 56 and anode 49 of diode 67 between these two intermediate points of the bridge produces substantially zero effect in the absence of a signal, because then there is substantially zero current through this diode.

Since the output of the intermediate frequency amplifier, or repeater, 34 is coupled to the output electrodes 49 and 56 of the diode control device 67, through the tube 42 and associated coupling systems, the average output electrode current of diode 67 is changed in response to a signal. This change is an increase, since the current is otherwise substantially zero.

When a carrier-frequency voltage is impressed on diode 67 from coil 47, there is produced by a rectification a direct current which flows through the bridge and divides between resistors 68 and 69, increasing the current in the former resistor and decreasing the current in the latter resistor and in diode 58. Therefore, there is superimposed upon the initial voltage of the intermediate point 55 a unidirectional rectified voltage having an average value approximately equal to the root-mean-square value of the carrier-frequency voltage impressed upon diode 67. The average rectified voltage is dependent on the carrier and independent of modulation, because this constitutes a form of linear detection, and therefore the rectified voltage is an undistorted replica of the modulated-carrier envelope. To produce this result, condenser 61 connected between cathode 56 and the intermediate point 55, is so small that its charging current is negligible at audio frequencies. Condenser 62 connected between point 60 and ground is so large that its audio-frequency impedance is considerably less than that of resistor 69, and therefore the audio-frequency voltage at point 60 is negligible at all times, regardless of the impedance of diode 58. Condenser 62 is a means for preventing modulation-frequency voltage fluctuations across the unidirectional conductor, diode 58.

A conductor 63, including a resistor 64, leads from intermediate point 60 to the lower ends of

secondary winding 14 and of the secondary windings of transformers 21 and 35. This conductor 63 applies an automatic volume control bias from point 60 to the control grid electrodes 17, 19 and 33 of tubes 18, 20 and 34, respectively. Normally, that is, in the absence of a signal, the point 60, and hence the grids 17, 19 and 33, are maintained slightly negative relative to the cathodes of the respective tubes by reason of the location of the bias resistors 95, 24 and 65, respectively, between these cathodes and ground, and the fact that point 60 is then substantially at ground potential.

The connection points, A, B, C and D, have no particular significance in Fig. 1, other than being connection terminals corresponding to those similarly lettered in Figs. 3 and 4 which show arrangements which may be substituted for the "Avc rectifier" in the dotted rectangle to the right of these four terminals of Fig. 1.

Fig. 2 is a graph of average rectified voltage plotted against carrier-frequency voltage, and which shows the approximate relations in the rectifier and suspender-diode circuit as a function of the carrier-frequency voltage applied to diode 67. The straight line 50 shows the average voltage of the diode anode 49 and of the junction point 55 relative to ground, which voltage changes in the negative direction in proportion to the impressed carrier voltage. The chart is based on an arrangement in which the total voltage of sources 70 and 71 is 90 volts, source 70 accounting for 30 volts and source 71 for 60 volts. For this relationship of voltages, the magnitude of high resistor 68 should be double that of high resistor 69, to maintain point 55 at the same initial voltage as the junction between sources 70 and 71. In the absence of a signal, point 55 is 30 volts positive relative to ground, as indicated by the upper left-hand end of line 50. When a carrier-frequency voltage is applied to the rectifier 67, the voltage across resistor 68 varies according to dimension 51, and the voltage across resistor 69 varies according to dimension 52. When the signal intensity increases to the point where the voltage of junction point 55 becomes negative, the current in diode 58 and the average current in resistor 69 are reduced to zero, and the voltage of point 60 then becomes equal to the average voltage of point 55. The voltage of point 60 relative to ground is indicated by dimension 53, and is shown to change from zero in the negative direction, when the carrier-frequency voltage exceeds 30 volts. The voltage of point 60, which is proportional to the excess of the voltage at point 55 above the given fixed value of 30 volts, is applied by the conductor 63 to the control electrodes of the controlled tubes 18, 20 and 35.

In the operation of the "suspended" automatic volume control, the connection 63 causes the control grids of the controlled tubes to become more negative only when the received signal voltage increases above a predetermined threshold value, thereby maintaining the amplified signal output level nearly uniform. The modulation of the received signal is prevented from affecting the automatic volume control bias, in the following manner: The rectified voltage at point 55 is an undistorted replica of the modulation envelope, and therefore the average rectified voltage is equal to the rectified carrier voltage, for any modulation not exceeding unity. Since the audio-modulation-frequency components of rectification are bypassed by condenser 62, the automatic volume control bias and the effect of the sus-

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pender diode 58 depends only on the carrier voltage. This type of "suspended" automatic volume control, utilizing the suspender diode 58, which fails to exert any volume controlling influence until the carrier voltage exceeds a predetermined value, is a preferred method of performing this result. This advantage, including freedom from effects of modulation, is not obtained in the usual systems now in use.

10 In the particular receiver under discussion, it is desired that the amplification be capable of 100 decibels variation by the automatic volume control action, in order that received signals varying in intensity from 10 micro-volts to 1 volt may be amplified to a nearly uniform output. This requires that the bias represented by the dimension 53 in Fig. 2, applied to the control grids of the controlled tubes, shall vary from zero to about 30 volts negative relative to ground, corresponding to the above minimum and maximum received signal voltages. The production of this wide variation of control bias requires that the carrier-frequency voltage applied to diode 67 shall vary from about 30 to 60 volts over the same range of received signal voltage, smaller signal voltages producing no volume control bias. These relationships are represented in Fig. 2.

Fig. 3 shows a volume control circuit which may be substituted for that part of the receiver of Fig. 1 which is included in the dotted rectangle labelled "Avc rectifier" at the right of the connection points A, B, C and D. The terminals A, B, C and D of Fig. 3 are intended to be connected respectively to the connection points A, B, C and D of Fig. 1. The principal difference between the circuit in Fig. 3 and the corresponding circuit in Fig. 1, is the substitution of a tapped-resistor voltage divider for the unitary tapped direct-voltage source of Fig. 1, and the replacement of the suspender diode by a resistor. In the circuit of Fig. 3, current from a direct voltage source 72 is passed through the series-connected voltage divided resistors 73, 74, 75 and 76. A resistor 77 is connected between point 60 and point 78, the latter point being the negative end of voltage source 72. The series resistors 68, 69 and 77 are collectively a high resistor, or a high-resistance direct-current path, the ends of which are connected respectively to two different points on the voltage source.

In the circuit of Fig. 3, when an average signal is applied to the rectifier 67, the rectified current divides, part flowing through resistor 68 in the direction to increase the auxiliary direct current normally flowing therein, and the other part flowing through resistors 77 and 69 in the opposite direction, to decrease and even to reverse the current normally flowing in these latter resistors. In this respect, the operation of the bridge circuit is similar to that of the corresponding bridge circuit in Fig. 1. In the absence of a signal, point 60 is normally slightly negative relative to the cathodes of the controlled tubes; and to insure this relationship, the intermediate point 60 is maintained normally at substantially the same voltage as the intermediate point between resistors 75 and 76 of the voltage source, this latter point being connected to ground, and through bias resistors to the said cathodes. Hence, the bias voltage on the control grids of tubes 18, 20 and 34 is maintained normally slightly negative relative to the respective cathodes by the volume-control bias connection 63. In the presence of a signal at rectifier 67, point 60 becomes negative, relative to ground, because the rectified current

reduces the voltage across resistor 77. Therefore the control grids of tubes 18, 20 and 34 become more negative relative to the respective cathodes in the presence of a signal.

Resistors 73, 74, 75 and 76 carry considerable direct current, so that the direct voltages across them are not appreciably affected by relative small changes in current through these resistors, corresponding to space current in the tubes connected thereto.

In the arrangements of Figs. 1 and 3, the rectifier electrodes 49 and 56 are both maintained normally substantially positive relative to ground, the anode 49 becoming negative in the presence of a sufficiently large signal voltage.

In Fig. 4, there is shown a circuit somewhat similar to that in Fig. 3, which is also adapted to be substituted for the "Avc rectifier" circuit in Fig. 1. Terminals A, B, C and D are intended to be connected respectively to connection points A, B, C and D of Fig. 1. In the circuit of Fig. 4, the rectifier electrodes are maintained normally substantially negative, instead of substantially positive, relative to ground. The series-connected resistors 68, 69 and 77 of Fig. 3 are replaced in Fig. 4 by three series resistors 79, 80 and 81, respectively, which will in general be of values somewhat different from those of the corresponding resistors of Fig. 3. The cathode of the rectifier 67 is connected to the intermediate point between voltage-divider resistors 75 and 76. The intermediate point between resistors 74 and 75 is grounded. The rectifier cathode 56 is thereby maintained substantially negative relative to ground. Terminal C, which is intended to connect with the lower end of coil 47, is connected at point 55 which, in this case, is the intermediate point between resistors 80 and 81. Point 55 is maintained at substantially the same voltage as the cathode 56, in the absence of a signal. Terminal D, which is intended to connect with the automatic volume control lead 63, is taken from the point 60 which, in this case, is the intermediate point between resistors 79 and 80.

In the operation of the system of Fig. 4, the rectified current, in the presence of a signal, divides as in the systems of Figs. 1 and 3. Part of the rectified current flows through resistors 79 and 80 in the direction to increase the current therein, and the other part flows through resistor 81 in the opposite direction to decrease, or possibly reverse, the current normally flowing in the latter resistor. Point 60 is normally slightly negative relative to the cathodes of tubes 18, 20 and 34, but becomes more negative in the presence of a signal.

The behavior of the automatic volume control in Fig. 1 is described briefly in this application, as well as in my said application, Serial No. 691,927, and in my said Letters Patent, Nos. 1,879,861, 1,879,862 and 1,879,863. In all these arrangements, the operation of the automatic volume control depends on a slight variation of the signal output voltage applied to the control device. When the received signal increases considerably, the signal output tends to increase in the same ratio. The control device then tends to excessively reduce the amplification of the signal. These two tendencies are counteractive in nature, and therefore must reach an equilibrium in which each tendency plays a part. As a result, the signal output increases slightly and the amplification is simultaneously reduced by a considerable amount. The less the former effect, in general, the more nearly perfect is the automatic control.

The suspended automatic volume control is an improvement which permits a closer approach to perfection, because a relatively small ratio of variation of the signal output applied to the control device, produces a very large variation of amplification. Other expedients have been proposed to achieve a similar improvement, but these have not combined simplicity and freedom from effects of modulation. Both these qualities are combined in the present invention, as shown in Fig. 1.

The invention has been described with reference to the complete receiver arrangement shown in Fig. 1. The automatic volume control in this receiver is classified as "regressive", because the repeating device whose performance is regulated (tubes 18, 32 and 34) is electrically antecedent in the system, with respect to the point 43 from which the signal is coupled to the control device 67. It is also characteristic of regressive automatic volume control, as of the arrangement of Fig. 1, that the signal voltage coupled to the control device depends on the regressive control action.

Another kind of automatic volume control is classified as "progressive", and is in some respects the opposite of "regressive." This other kind of control is called "progressive" because the repeating device whose performance is regulated is electrically subsequent in the system, with respect to the point from which the signal is coupled to the control device. It is also characteristic of progressive automatic volume control, that the signal voltage coupled to the control device is independent of the progressive control action.

In some cases it may be advantageous to combine both regressive and progressive controls, since they are well adapted to cooperating in combination. Regressive control, with or without the cooperation of progressive control, is preferred where the received signal voltage is subject to a wide range of variation, as in radio-broadcast receivers.

The present invention is not limited in its application to regressive automatic volume control, shown in Fig. 1, but is equally applicable to progressive control, or to both together. Progressive control in Fig. 1 is readily effected by applying the control bias from the lead 63 to the control electrode 38 in the repeater-amplifier vacuum tube 39, which is subsequent to the point 43 from which the signal is coupled to the control device 67. Likewise, the modifications of Figs. 3 and 4 are equally applicable to progressive control.

The same elements in the several figures are designated by the same reference characters. Although the sources of operating voltage in the foregoing figures are symbolized as batteries, it is understood that any means for supplying direct voltage may be used, preferably a rectified and filtered alternating-current power supply.

I claim:

1. In a signaling system, a signal repeater having a control electrode, a source of direct current for supplying space current in said repeater, a high-resistance direct-current path between two different points on said source, a connection between said control electrode and a first intermediate point on said path, a diode rectifier having one electrode connected to a second intermediate point on said path and its other electrode connected to a point on said source at a potential substantially the same as the normal potential

of said second intermediate point, and means for coupling the output of said repeater to said rectifier for controlling the average rectifier current in response to a signal, the resistance of said direct-current path being so related to said average output-electrode current that the voltages of said intermediate points are changed by said change of average output-electrode current by an amount at least on the order of the normal voltages of said points, whereby the responsiveness of said repeater is regulated automatically.

2. In a signaling system, a signal repeater having a control electrode, a source of direct current for supplying space current in said repeater, a high-resistance direct-current path between two different points on said source, a connection between said control electrode and a first intermediate point on said path, a diode rectifier having one electrode connected to a second intermediate point on said path and its other electrode connected to a point on said source at a potential substantially the same as the normal potential of said second intermediate point, and means for coupling said signal repeater to said rectifier for increasing the average rectifier current, the resistance of said direct-current path being so related to said average output-electrode current that the voltages of said intermediate points are changed by said change of average output-electrode current by an amount at least on the order of the normal voltages of said points, whereby the responsiveness of said repeater is regulated automatically.

3. In a signaling system, a vacuum-tube signal repeater having a direct-current source for supplying space current therein, a high-resistance direct-current path connected between two different points on said source, a diode rectifier connected respectively to a point on said source and a first intermediate point on said path normally at a potential substantially the same as said point on said source, a control electrode in said repeater connected to a second intermediate point on said path, and means for coupling the output of said repeater to said rectifier for increasing the average electrode current in response to a signal, the resistance of said direct-current path being so related to said average output-electrode current that the voltages of said intermediate points are changed by said change of average output-electrode current by an amount at least on the order of the normal voltages of said points, whereby the voltage on said control electrode is changed and the responsiveness of said repeater is thereby regulated automatically.

4. In a signaling system, a vacuum-tube signal repeater having a direct-current source for supplying space current therein, a high-resistance direct-current path connected between two different points on said source, a diode rectifier connected respectively to a point on said source and a first intermediate point on said path normally at a potential substantially the same as said point on said source, a control electrode in said repeater connected to a second intermediate point on said path, and means for coupling said signal repeater to said rectifier for increasing the average electrode current, the resistance of said direct-current path being so related to said average output-electrode current that the voltages of said intermediate points are changed by said change of average output-electrode current by an amount at least on the order of the normal voltages of said points, whereby the voltage on said control electrode is changed and the respon-

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siveness of said repeater is thereby regulated automatically.

5. In a signaling system, a signal repeater having a control electrode connected to an intermediate point on a high resistor, a source of direct current for supplying space current in said repeater, a diode rectifier having one electrode connected to a second intermediate point on said resistor and its other electrode connected to a point on said source at a potential substantially the same as the normal potential of said second intermediate point, two connections from different points on said source to the ends of said resistor for maintaining said electrodes at desired normal voltages in the absence of a signal, and means for coupling the output of said repeater to said rectifier for increasing the average electrode current in response to a signal, the resistance of said resistor being so related to said average output-electrode current that the voltages of said intermediate points are changed by said change of average output-electrode current by an amount at least on the order of the normal voltages of said points, whereby the responsiveness of said repeater is regulated automatically.

6. In a signaling system, a signal repeater having a control electrode connected to an intermediate point on a high resistor, a source of direct current for supplying space current in said repeater, a diode rectifier having one electrode connected to a second intermediate point on said resistor and its other electrode connected to a point on said source at a potential substantially the same as the normal potential of said second intermediate point, two connections from different points on said source to the ends of said resistor for maintaining said electrodes at desired normal voltages in the absence of a signal, and means for coupling said signal repeater to said rectifier for increasing the average electrode current, the resistance of said resistor being so related to said average output-electrode current that the voltages of said intermediate points are changed by said change of average output-electrode current by an amount at least on the order of the normal voltages of said points, whereby the responsiveness of said repeater is regulated automatically.

7. In a signaling system, a vacuum-tube signal amplifier having a direct-current source for supplying the space current thereof, a high resistor connected between two points of substantially different potential on said source, a diode rectifier having a cathode connected to a point on said source intermediate said two points and an anode connected to a first intermediate point on said resistor, said amplifier having a cathode connected to a different intermediate point on said source and a control electrode connected to a second intermediate point on said resistor negative relative to said amplifier cathode, and means for coupling the output of said amplifier to said rectifier and thereby increasing the average current of said rectifier in response to an amplified signal, whereby the amplification in said amplifier is regulated automatically.

8. In a signaling system, a vacuum-tube signal amplifier having a direct-current source for supplying the space current thereof, a high resistor connected between two points of substantially different potential on said source, a diode rectifier having a cathode connected to a point on said source intermediate said two points and an anode connected to a first intermediate point on said resistor, said intermediate points being at

substantially the same voltage in the absence of current in said rectifier, said amplifier having a cathode connected to a different intermediate point on said source and a control electrode connected to a second intermediate point on said resistor negative relative to said amplifier cathode, and means for coupling the output of said amplifier to said rectifier and thereby increasing the average current of said rectifier in response to an amplified signal, whereby the amplification in said amplifier is regulated automatically.

9. In a signaling system, a vacuum-tube signal amplifier having a cathode and a control electrode, a diode rectifier coupled to the output of said amplifier, a high resistor connected across a direct-voltage source, a connection between the anode of said rectifier and a first intermediate point of said resistor, a connection between said control electrode and a second intermediate point of said resistor which is negative relative to said first point and to said amplifier cathode, and a connection from the cathode of said rectifier to a point of said source which is at substantially the same voltage as said first intermediate point in the absence of a signal, whereby the space current of said rectifier is divided between the portions of said resistor on either side of said first intermediate point, thereby causing said control electrode to become increasingly negative with increase of amplifier output, whereby the amplification in said amplifier is regulated automatically.

10. In a signaling system, a vacuum-tube signal amplifier having a cathode and a control electrode, a diode rectifier coupled to the output of said amplifier, a series circuit including a high resistor and a direct-voltage source, a connection between a point on said source and the cathode of said rectifier, a connection between the anode of said rectifier and a first intermediate point on said resistor at substantially the same voltage as said point on said source in the absence of a signal, a connection between a different point on said source and the amplifier cathode, and a connection between said control electrode and a second intermediate point on said resistor negative relative to said different point on said source, whereby the space current of said rectifier is caused to divide between the portions of said resistor on either side of said first intermediate point, thereby causing said control electrode to become increasingly negative with increase of amplifier output, whereby the amplification in said amplifier is regulated automatically.

11. In a signaling system, a vacuum-tube signal amplifier having a cathode and a control electrode, a diode rectifier coupled to the output of said amplifier, a series circuit including a high resistor and a source of direct voltage for effecting a substantial direct current through said circuit in the absence of a signal, means for causing the space current of said rectifier to divide between two portions of said resistor having a common junction point, the electrodes of said rectifier being connected respectively to said junction point and to another point in said circuit having relative to said junction point such a voltage as to cause no substantial current in the rectifier in the absence of a signal, a connection between said control electrode and a different point on said resistor, and a connection between said cathode and a point on said source, said points on said resistor and therefore said control electrode being subject to a change of average voltage relative to said cathode with increase

of amplifier output, whereby the amplification in said amplifier is regulated automatically.

12. In a signaling system, a vacuum-tube signal amplifier having a cathode and a control electrode, a diode rectifier having an anode and a cathode, a high resistor having a first intermediate point connected to said anode and a second intermediate point connected to said control electrode, means for maintaining in the absence of a signal a substantial value of average voltage between said points and a slightly negative voltage on said second point relative to said amplifier cathode, means for maintaining said rectifier cathode at a substantially constant voltage substantially equal to the voltage of said rectifier anode relative to said amplifier cathode in the absence of a signal, and means for coupling the output of said amplifier to said rectifier and thereby negatively changing the average voltage on said anode and the voltage on said control electrode in response to an amplified signal, whereby the amplification in said amplifier is regulated automatically.

13. In a modulated-carrier signal receiver, an arrangement responsive to carrier intensity and unresponsive to modulation for controlling the amplification in the system, said arrangement including: a carrier amplifier for producing an amplified carrier output; a series circuit including a resistor and a unidirectional conductor having relative to said resistor much less resistance to current in the more conductive direction and much more resistance to current in the other direction; means for maintaining a substantial unidirectional current through said circuit in the absence of a signal; means for producing a unidirectional reduction of voltage across said circuit directly proportional to the modulation envelope of said amplified carrier output and in the direction to reduce said unidirectional current; means for substantially attenuating the resulting modulation frequency voltage fluctuations across said conductor; and means for utilizing the resulting unidirectional voltage across said conductor for reducing the gain of said receiver with increasing output carrier amplitude when the output carrier amplitude exceeds the value required to reduce said unidirectional current to zero.

14. In a signaling system, an amplifier having cathode and control electrode, a direct voltage source having its negative end connected to said cathode, a high resistance having one end connected to the positive end of said source, a diode rectifier responsive to the output of said amplifier, said rectifier having an anode connected to a tap on said resistance and a cathode connected to a tap on said source, said taps dividing the resistance and the source in about the same ratio, a second diode having an anode connected to the other end of said resistor and a cathode connected to the amplifier cathode, and a connection from said second diode anode to said control electrode, whereby the amplification is regulated automatically only when the signal exceeds the value required to carry said output electrode more negative than said amplifier cathode.

15. In a modulated-carrier signal receiver, a carrier amplifier for producing an amplified carrier output, means responsive to said carrier output for producing across a resistance a unidirectional voltage having a variation of its average value proportional to the amplitude of said carrier output and independent of the modulation of said carrier, means including a unilaterally

conductive device connected in circuit with said resistance for deriving therefrom a unidirectional voltage proportional to the excess of said average variation over a predetermined substantial value only when said average variation exceeds said predetermined value, low-pass filtering means interposed between said resistance and said device for preventing modulation-frequency currents in said device, and means for utilizing said derived voltage for varying the amplification in said receiver inversely with the amplitude of said carrier output.

16. In a modulated-carrier signal receiver, a resistance network, means for producing a direct current in said network, a unilaterally conductive device connected between points of said network normally effective to produce a current therethrough, means for producing in at least a portion of said network a unidirectional current in opposition to the first said current and varying in accordance with the amplitude of said carrier, and voltage utilization means for controlling the gain of said receiver effectively connected for carrier amplitudes below a predetermined value, through said device to a predetermined point of fixed potential, said opposing current being effective at said value to interrupt the current through said device, and said utilization means being effectively connected for carrier amplitudes above said value, to a point of said network the potential of which varies substantially in accordance with said carrier amplitude.

17. In a modulated-carrier signal receiver, a resistance network, means for producing a direct current in said network, a unilaterally conductive device connected between points of said network normally effective to produce a current therethrough for maintaining said points at substantially the same potential, means for producing in at least a portion of said network a unidirectional current in opposition to the first said current and varying substantially in accordance with the amplitude of said carrier, said opposing current being effective at a predetermined value to interrupt the current through said device and at greater values to effect a difference in potential between said points varying in accordance with its amplitude, and voltage utilization means connected across said points for controlling the gain of said receiver.

18. In a modulated-carrier signal receiver, a bridge circuit the arms of which comprise a source of direct voltage and a high resistor through which current normally flows, a diode rectifier connected between intermediate points of said arms normally at substantially the same potential, said rectifier being actuated by a received signal to produce in at least a part of the resistance arm of said bridge a current in opposition to the first said current and of average value proportional to the carrier amplitude and independent of the modulation of said carrier, and voltage utilization means for controlling the gain of said receiver connected to points on said arms the potential difference of which is varied by said opposing current in accordance with the amplitude thereof at least for opposing currents above a predetermined amplitude.

19. In a modulated-carrier signal receiver, a bridge circuit the arms of which comprise a source of direct voltage and a high resistor through which current normally flows, a unilaterally conductive device connected in the resistance arm of said bridge, one terminal of said

device being at fixed potential, a diode rectifier connected between intermediate points of said arms normally at substantially the same potential, said rectifier being energized by a received
5 signal to produce in at least the part of said resistance arm including said device a current in opposition to the first said current and of average value proportional to the carrier amplitude, said opposing current being effective for carrier
10 amplitudes above a predetermined value to interrupt the current through said device, and voltage utilization means connected across said device for controlling the gain of said receiver, thereby to provide a predetermined fixed control
15 potential for carrier amplitudes below said predetermined value and a control potential which varies in accordance with the carrier amplitude for carrier amplitudes above said value.
20 20. In a modulated-carrier signal receiver, a resistance network, means for producing a flow of unidirectional current in said network, a unilaterally conductive device connected between

points of said network normally effective to cause a current therethrough, a diode rectifier for deriving from the modulated carrier a unidirectional voltage of average value varying in
5 accordance with the carrier amplitude and independent of the modulation thereof and effective to produce in at least a portion of said network a direct current in opposition to said first current, and voltage utilization means for controlling the gain of said receiver effectively connected,
10 for carrier amplitudes below a predetermined value, through said device to a predetermined point of fixed potential, said opposing current being effective at said value to interrupt the current through said device and said utilization
15 means being effectively connected, for carrier amplitudes above said value, to a point of said network the potential of which varies substantially in accordance with said carrier amplitude.
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