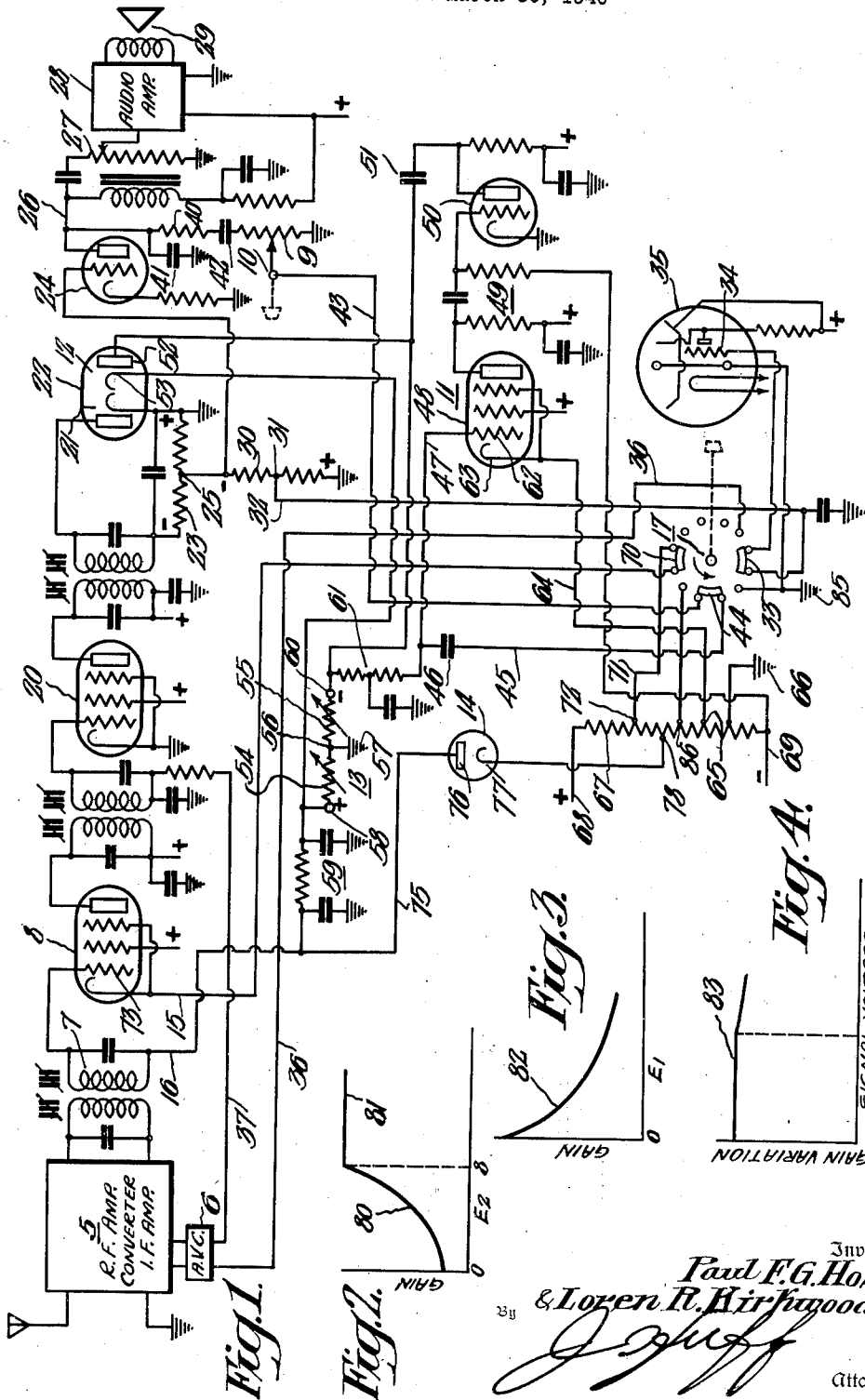


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VOLUME RANGE CONTROL SYSTEM

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VOLUME RANGE CONTROL SYSTEM

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This invention relates to volume range control systems embodying signal amplifying means the gain of which is increased and decreased in accordance with variations in the volume level or average amplitude of applied signals, or the modulation component thereof, to cause volume range expansion or contraction to a predetermined degree, or alteration of the original volume or amplitude variation in a predetermined manner, at the output end of the system.

It is an object of the present invention to provide an improved volume range control system of the character referred to, which is adapted to be embodied in a radio receiving system or other signal conveying and amplifying channel, and which comprises a simplified circuit arrangement and is highly stable in operation.

It is also a further object of the present invention, to provide an improved volume range expander system for radio receiving systems and the like, having means for preventing extension of the expansion range to cause overload of the amplifying means employed, together with means in the expander system for stabilizing the operation thereof.

The invention will, however, be better understood from the following description, when considered in conjunction with the accompanying drawing, and its scope is pointed out in the appended claims.

In the drawing, Figure 1 is a schematic circuit diagram of a radio signal receiving system embodying the invention, and Figures 2, 3 and 4 are curves illustrating certain operating characteristics of the system of Figure 1.

Referring to Fig. 1, 5 represents the tuning portion of a radio receiving system wherein signals are selected and amplified under control of automatic volume control means 6. In the present example, the portion 5 may be taken to represent the tunable R.-F. amplifier, converter and oscillator, together with the first stage I.-F. amplifier of a superheterodyne receiver provided with an automatic volume control means 6 which is preferably of the parallel type. This portion of the receiving system, however, may be of any suitable type adapted to provide selected and controlled signals in the signal conveying channel of the system, at the input circuit of a controlled amplifier, represented by the I.-F. amplifier stage 8.

The volume range control means associated with the stage 8 comprises an expander or attenuator control potentiometer 9—10, a volume range control amplifier 11 and rectifier 12, a bias

control circuit 13, and an interlocking diode rectifier 14 connected to the stage 8 through a cathode lead 15, a bias potential supply lead 16, and a selector control switch 17.

In the present example, the controlled amplifier stage 8 is the second I.-F. amplifier stage, representing any suitable number of amplifier stages in the signal amplifying channel of the receiving system adapted for variable gain control. In the circuit shown, the gain is varied by variation in biasing potential applied to the stage 8 between the leads 15 and 16 in response to the variations in modulation depth.

It may be assumed also that the stage 8 is arranged to provide volume range expansion in the signal channel, although it should be understood that, depending upon the direction of change in biasing potential, the control stage 8 readily may provide volume range contraction as well as expansion.

The signal receiving channel further includes, by way of example, a third intermediate frequency amplifier stage 20 and a second or audio frequency detector 21 coupled thereto and included in the same envelope 22 with the rectifier 12. It will be noted that the stage 20 is provided with a connection 37 whereby it is controlled by the A. V. C. means 6.

The second detector 21 is preferably of the diode type, as shown, having a signal output impedance 23 to which a first stage audio frequency amplifier 24 is coupled at a tap point 25 for deriving therefrom a portion of the detected audio frequency signals. The amplifier stage 24 is provided with an output circuit 26 which is coupled through a volume control device 27 to the remainder of the audio frequency amplifier indicated at 28 and a loudspeaker device 29.

The second detector output circuit also includes a potential divider 30 connected in shunt with a portion of the output resistor 23 and having an output tap 31 connected through a lead 32 and a contact element 33 of the switch 17 with the control electrode 34 of a tuning indicator device 35 which, as shown, may be a usual tuning indicator tube of the cathode ray type at present well known and extensively used in receiving systems. However, any polarized or bias potential responsive indicator may be used. In the present example, the bias potential is provided by signal rectification in the second detector and is the D.-C. component of the rectified signal having a polarity as indicated.

By operation of the switch 17 in the direction

of the arrow, the contact element 33 provides a connection for the control electrode 34 with a lead 36 which in turn is connected to the automatic volume control means 6 of the receiving system, so that the tuning indication may be taken therefrom. When connected to the A. V. C. means, the tuning indication is as normally provided in the usual receiving system.

With the present connection, the device 35 provides a measure of the variation in the signal amplitude applied to the second detector in response to the variation in gain of the amplifier stage 8, thereby indicating the degree of volume range expansion or contraction provided as the potential between the leads 15 and 16 is varied.

The control voltage responsive to variation in modulation depth of the received signal or the modulation component of the signal provided by the expander control device 9, is derived from the signal channel of the receiving system preferably following the first audio frequency amplifier stage 24 at the output circuit 26, although it may be derived from any other suitable point in the signal channel, after the audio signal detector.

For this purpose, in the present example, the expander control device 9 is connected in shunt with the signal channel across the output circuit 26 of the first audio frequency amplifier stage 24 and in series with a resistor 40 and a blocking capacitor 42. An intermediate frequency by-pass capacitor 41 is also included in this circuit.

The circuit arrangement is such that movement of the contact 13 of the potentiometer device 9 in an upward direction as viewed in the drawing provides an increasing audio frequency signal potential for the control amplifier. This potential is applied through a circuit including a connection lead 43, a contact element 44 on the switch 17, a lead 45 and a coupling capacitor 46, to the input grid circuit 47 of the expander amplifier 11.

The demodulated or audio frequency signals thus applied are amplified by the first stage 48 and are conveyed therefrom through a suitable coupling circuit 49 to a second stage amplifier 50 which in turn is coupled through an output coupling capacitor 51 to the expander or volume range control rectifier 12 comprising an anode 52 and a cathode 53 shunt-connected with an output impedance comprising two resistor sections 54 and 55 having a midterminal 56 connected to ground 57.

The polarity of the rectifier is such that in response to received signals the terminals of the impedance are polarized as shown, the positive terminal 58 being connected through a time-delay filter network 59 with the grid circuit 16 of the controlled amplifier 8, while the negative terminal 60 is connected through a second time-delay filter network 61 with the control grid or input circuit 47 and the control grid 62 of the first stage of the expander or control amplifier 11.

The cathode 63 of the control amplifier stage 48 is connected through a lead 64 with a terminal 65 positive with respect to ground 66, on a potential source provided by a potential supply resistor 67, the positive and negative supply leads of which are indicated at 68 and 69 respectively. The cathode tap 65 is normally substantially 3 volts positive above ground 66 so that, in the absence of signals, the biasing potential applied to the grid 62 through ground 57, resistor section 55, and filter 61, is three volts negative with respect to the cathode.

The cathode lead 15 of the amplifier 8 is con-

nected through a contact element 70 and a lead 71 with a positive terminal 72 on the potential supply resistor 67 which may be substantially 11 volts positive with respect to ground 66, thus placing an initial negative bias of substantially 11 volts on the input or control grid 73 of the amplifier 8 through the ground connection 57, resistor section 54, and the filter 59, thence through the lead 16 and the input circuit 7. In this connection, it should be noted that the tubes 8 and 48 are preferably of the variable mu type to provide a wide range of control without distortion.

With the arrangement shown, as the modulation depth of the signal increases or as the contact 13 is moved to apply a greater portion of the audio frequency voltage across resistor 9 to the amplifier 11, the voltage output from the rectifier 12 across the resistor sections 54 and 55 in series, causing the negative biasing potential on the grid 73 of the expander-controlled amplifier 8 to decrease, thereby increasing the gain of the signal channel of the receiving system and providing volume range expansion in accordance with increases in the modulation depth or in the amplitude of the derived signal modulation.

When the signal reaches a maximum permissible value, the interlocking diode 14 comes into operation to prevent a further decrease in the biasing potential on the controlled amplifier 8. This is effected through a connection for the anode 76 of the interlocking diode 14 with the negative grid lead 16, while the cathode 77 is connected to a positive potential point 78 on the supply resistor 67 which is substantially 3 volts more negative than the terminal 72, or substantially 3 volts above ground in the present example.

Thus, when the output of the expander rectifier at the terminal 58 reaches a positive potential of 8 volts, the rectifier operates to maintain that voltage fixed, since it rectifies at a potential above that value and thus limits the biasing potential on the amplifier 8 to substantially 3 volts negative which is assumed in the present example to provide maximum gain. This value, however, may be adjusted to any suitable level for the particular amplifier tube used.

At the same time that the negative biasing potential on the grid 73 of the controlled amplifier 8 is decreased, the negative biasing potential on the control grid 62 of the control amplifier tube 48 is increased, since it is connected to the negative terminal 60 of the diode output resistor 54—55. Therefore, in response to applied signals and an increase in the percentage modulation or modulation depth, the biasing potential on the control grid 73 of the main amplifier 8 in the signal channel is decreased, while that on the control grid 62 in the control amplifier channel is increased, resulting in increased gain in the main channel and decreased gain in the control channel. The circuit providing this control arrangement includes an intermediate tap 56 on the resistor 54—55 connected to ground, while the positive and negative terminals 58 and 60, respectively, are connected to the two channels to control the biasing potential and gain in the two channels in an opposite sense one with respect to the other as above pointed out.

From the foregoing description, it will be seen that the main signal amplifying channel of a receiving system is provided with amplifying means such as the R.-F., first detector, first I.-F. at 5, and a third I.-F. amplifier 20 under control of A. V. C. means which provides substan-

tially flat A. V. C. action in that the output of the second detector 22 is made substantially constant with variations in signal strength, that is, variations in the amplitude of a carrier wave applied to the input circuit. By this means, the output of the audio frequency or second detector is proportional to the modulation depth or percentage modulation of the carrier wave and substantially independent of the signal or carrier wave strength.

At a suitable point following the second detector, such as the output circuit 26 of the first audio frequency amplifier stage, a signal is derived across a variable potential-controlling device or potentiometer 9—10 and is applied to a rectifier 12 through a suitable control amplifier channel 11.

The rectifier 12 is provided with an output resistor or impedance 54—55 which is connected to the common return circuit of the system at an intermediate point 56 thereby providing with respect to that point two control potentials, one positive and the other negative, which vary in accordance with variations in the modulation depth or percentage modulation of a received signal wave.

The positive potential is applied to the main signal amplifying channel at one or more stages, such as the stage 8 in the intermediate frequency amplifier shown, to vary the gain thereof and causing the output of the second detector 22 and the gain between the antenna and the second detector to vary in accordance with and to be dependent on modulation depth of the received signal and independent of the carrier wave strength.

In the absence of signals, the amplifier 8, controlled by the positive potential, is biased negatively sufficiently to reduce its gain to a desired minimum. The gain is permitted to rise to a maximum value determined by the interlocking diode 14 which, in the present example, is so biased that it prevents the reduction of the biasing potential on the amplifier 8 below -3 volts, which is assumed to be that at which the main signal channel has a maximum desired gain. Thus, the signal channel is prevented from causing signal distortion in the presence of relatively strong signals above the normal operating range of modulation variation.

If the resistor sections 54 and 55 of the control rectifier are substantially equal, the negative bias applied to the control amplifier 48 is the same as the positive potential applied to the main signal amplifier 8 and varies in exactly an opposite sense. However, the relative values of the two potentials may be adjusted by means of the resistors 54 and 55. Both the filter networks 59 and 61 provide a desired time delay in the application of the potential variation to the two amplifier channels.

The action of the rectifier 12 and the control of the two amplifier channels may be further understood with reference to Figs. 2, 3 and 4, to which attention is now directed along with Fig. 1.

Referring particularly to Fig. 2, as the positive potential at the terminal 58 is increased the gain of the stage 8 is increased as indicated by the curve 80 and continues to increase until the interlocking diode 14 comes into operation and holds the negative bias at the predetermined value, which in this case is 3 volts. When the gain would tend to further increase, the applied

positive potential causes no increase in the gain as indicated by the portion 81 of the curve in Fig. 2.

The control voltage for the main amplifier stage 8 designated as E_2 is proportional to the audio frequency input to the expander or control rectifier 12 and is proportional to the modulation depth, being the voltage between the terminals 56 and 58 across the resistor 54, as hereinbefore described.

If the system is operating in equilibrium at a certain average percentage modulation and the modulation depth is increased, the result will be greater control voltage E_2 which, in turn, will cause the gain of the second I.-F. amplifier 8 to increase, thereby resulting in a further increase in E_2 by reason of the increased gain in the main channel preceding the second detector 22 and the output circuit 26 from which the control audio frequency potential is derived.

In order to overcome this regeneration effect, which has been one of the disadvantages of previously known systems of this character, the control or expander amplifier 11 is provided with the amplifier stage 48 which operates inversely to the second I.-F. amplifier so that the voltage rectified in the expander rectifier 12 and the voltage across the output resistor 54—55 is made independent of the gain variations in the second I.-F. amplifier or main signal channel, whereby the rectified control voltage will depend only on the modulation depth or percentage modulation, and the system will operate with a desired stability throughout the control range.

Accordingly, the resistance of the resistor section 55 and the negative biasing potential, which may be designated E_1 , is made such that the gain in the amplifier stage 48 is reduced as the applied signal from the circuit 26 through the device 9—10 is increased following an increase in gain in the amplifier stage 8, by an amount such that the output potential from the amplifier 11 as applied to the rectifier 12 and the controlling potential across the resistors 54 and 55 does not change as a result of a change in gain in the amplifier 8.

In other words, the overall gain of the system from the input circuit 7 through to the control diode 12 is maintained substantially constant with changes in gain of the controlled amplifier 8.

The reduction in gain in the amplifier stage 48 is indicated by the curve 82 in Fig. 3, resulting in a substantially constant gain variation as shown by the curve 83 in Fig. 4 as the derived audio frequency signal voltage from the potentiometer 9—10 is varied.

Stated in other words, the variation in gain of the main signal amplifier channel for volume expansion or control purposes is prevented from becoming regenerative by inserting in the feedback loop or control channel an amplifier, the gain of which varies inversely with respect to the gain in the signal channel.

In case it is desired to operate the receiving system without the volume range control or expansion, the switch 17 is operated to move the contacts in the direction of the arrow causing the indicator tube 35 to receive signals direction from the A. V. C. means 6, as hereinbefore explained, and through the contact 45 grounding the input circuit 47 of the amplifier tube 48 through the ground connection 85 while the cathode lead 15 is connected through the con-

tact 70 to a bias potential tap 86 substantially 6 volts positive with respect to ground 66, whereby the gain of the amplifier 8 is set at a predetermined intermediate level.

While the volume expansion or volume control of the system has been shown and described in connection with a single I.-F. amplifier stage 8, it should be understood that the control may be applied to other amplifier stages or to any suitable means in an amplifying system for controlling the gain through the main signal channel, the gain control appearing between the signal input portion of the system and the point at which the controlling modulation or audio frequency signal is derived, with an amplifier and control rectifier interposed between the last-named point and the controlled amplifier, the gain of the interposed amplifier being variable inversely with the gain in the main channel in predetermined relation thereto as described.

We claim as our invention:

1. In a radio signal receiving system, the combination of a variable gain signal amplifier, an audio frequency detector coupled to said amplifier, volume range control means connected between the output of said detector and said amplifier for causing the output of said detector to vary proportional to the depth of modulation of received signals, and means for preventing feed back of gain variation in said amplifier.

2. In a radio signal receiving system, the combination of a signal amplifier having a gain control circuit, an audio frequency detector coupled to said amplifier, means including a volume range control circuit connected between the output of said detector and the gain control circuit of said amplifier for causing the output of said detector to vary substantially proportional to the depth of modulation of received signals and substantially independent of signal strength variation, and means for preventing gain variation of said signal amplifier from influencing the controlling function of said volume range control means.

3. In a signal amplifying system, the combination with a signal amplifier, of means for deriving rectified signals from said amplifier, amplifying means for said rectified signals, means for causing the gain of the first-named amplifier and said last-named amplifying means to vary inversely one with respect to the other in response to variations in the amplitude of said rectified signals, comprising a rectifier for said last named signals having an output circuit providing inversely variable controlling potentials, and circuits for applying said potentials to said signal amplifier and amplifying means.

4. In a signal amplifying system, the combination with a signal amplifier, of means for deriving rectified signals from said amplifier, amplifying means for said rectified signals, means for causing the gain of the first-named amplifier and said last-named amplifying means to vary inversely one with respect to the other in response to variations in the amplitude of said rectified signals, said last-named means comprising a control amplifier for said first-named rectified signals, a rectifier coupled to said control amplifier and having an output circuit including an output resistor provided with an intermediate control circuit terminal and having a positive and a negative terminal, means providing a filter connection between said positive terminal and the first named amplifier, and means providing a filter connection between said negative terminal and the last-named amplifying means.

5. A volume range control system comprising in combination, a modulated signal amplifier stage, a detector for receiving the amplified signal output therefrom, an output circuit for said detector, a second amplifier coupled thereto, a rectifier coupled to said second amplifier, an output impedance for said rectifier having positive and negative terminals, means providing a gain controlling connection for said first named amplifier with the positive terminal, and means providing a gain controlling connection for said second amplifier with the negative terminal, whereby the gain of said amplifiers vary inversely one with respect to the other in response to variations in the depth of the signal modulation.

6. In a superheterodyne radio signal receiving system, the combination with an intermediate frequency amplifier and an audio frequency detector coupled to said amplifier, of means for applying to said detector through said amplifier modulated signals substantially independent of signal strength variations, and means for applying to at least one stage of said intermediate frequency amplifier gain controlling potentials which vary in proportion to variations in the modulation depth of said signals thereby to provide volume range control of the output of said system, and means for rendering said potential variations substantially independent of variations in the gain of said intermediate frequency amplifier stage.

7. In a superheterodyne radio signal receiving system, the combination with an intermediate frequency amplifier and an audio frequency detector coupled to said amplifier, of means for applying to said detector through said amplifier modulated signals substantially independent of signal strength variations, means for applying to at least one stage of said intermediate frequency amplifier gain controlling potentials which vary in proportion to variations in the modulation depth of said signals thereby to provide volume range control of the output of said system, means for rendering said potential variations substantially independent of variations in the gain of said intermediate frequency amplifier stage, and means including a controlling rectifier connected in circuit with said intermediate frequency amplifier for limiting the range of volume control of said amplifier.

8. In a superheterodyne radio signal receiving system, the combination with an intermediate frequency amplifier and an audio frequency detector coupled to said amplifier, of means for applying to said detector through said amplifier modulated signals substantially independent of signal strength variations, means for applying to at least one stage of said intermediate frequency amplifier gain controlling potentials which vary in proportion to variations in the modulation depth of said signals thereby to provide volume range control of the output of said system, and means for rendering said potential variations substantially independent of variations in the gain of said intermediate frequency amplifier, said last-named means comprising an amplifier coupled to said signal circuit following said audio frequency detector for amplifying a portion of the signal output therefrom, a diode rectifier coupled to said last-named rectifier and having an output impedance having an intermediate terminal, and positive and negative terminals connected respectively with the first-named amplifier stage and with the last-named

amplifier for applying controlling potentials thereto, thereby inversely to control the gain in said amplifiers to provide an overall gain through said system to said last-named rectifier which is substantially independent of the gain variations in said intermediate frequency amplifier.

9. A volume range control system comprising, in combination, a main variable gain signal amplifying channel, means for rectifying a portion of the output of said channel to derive a controlling potential proportional to the modulation depth of said signals, said last-named means including a variable gain amplifier, means for rectifying the signal output from said last-named rectifier to provide a gain controlling potential for said first-named amplifier, and means for applying said potential to said first-named amplifying channel and to said last-named amplifier to cause the gain in said last-named amplifier to vary inversely with respect to the gain in the first-named amplifier, whereby said gain controlling potential is responsive to changes in the modulation depth of signals in said channel and substantially independent of variations in gain in said channel.

10. In a signal amplifying system, the combination of a signal amplifier stage having a cathode circuit and a control grid circuit, a rectifier circuit coupled to said amplifier stage, a second amplifier stage coupled to said rectifier means for amplifying the modulation component of a received signal, automatic volume control means connected with said signal amplifier stage for causing said derived modulation component to be substantially independent of signal strength variations, means coupled to said second amplifier stage for rectifying said derived modulation component including a rectifier having an output impedance providing a positive and a negative terminal and an intermediate tap, and means for deriving from said last-named impedance control potentials which vary inversely, and means for applying said control potentials to said amplifying system to maintain substantially constant input to said last-named rectifying means in the presence of signal strength and gain variations in said signal amplifier stage.

11. In a radio signal conveying channel, the combination of a controlled amplifier stage adapted for variable gain control by bias potential variations, said amplifier stage having an input circuit, means for selecting and applying modulated signals to said input circuit and volume range control means associated with said stage including a volume range control amplifier, an audio frequency detector interposed in circuit between said controlled amplifier stage and said volume range control amplifier, a signal rectifier coupled to said volume range control amplifier and providing rectified controlling potentials which vary inversely one with respect to the other, and means for applying said potentials to said controlled amplifier stage and to said volume range control amplifier to decrease the gain of said volume range control amplifier in response to an increase in the gain of said controlled amplifier stage whereby the amplifier system is stabilized in operation and the signals applied to said last-named rectifier are independent of variations in the gain of said controlled amplifier stage.

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