Dec. 27, 1938. P. F. G. HOLST ET AL 2,141,391

HIGH FIDELITY RADIO RECEIVER

Filed Aug. 29, 1936 2 Sheets-Sheet 1

Fig. 1.

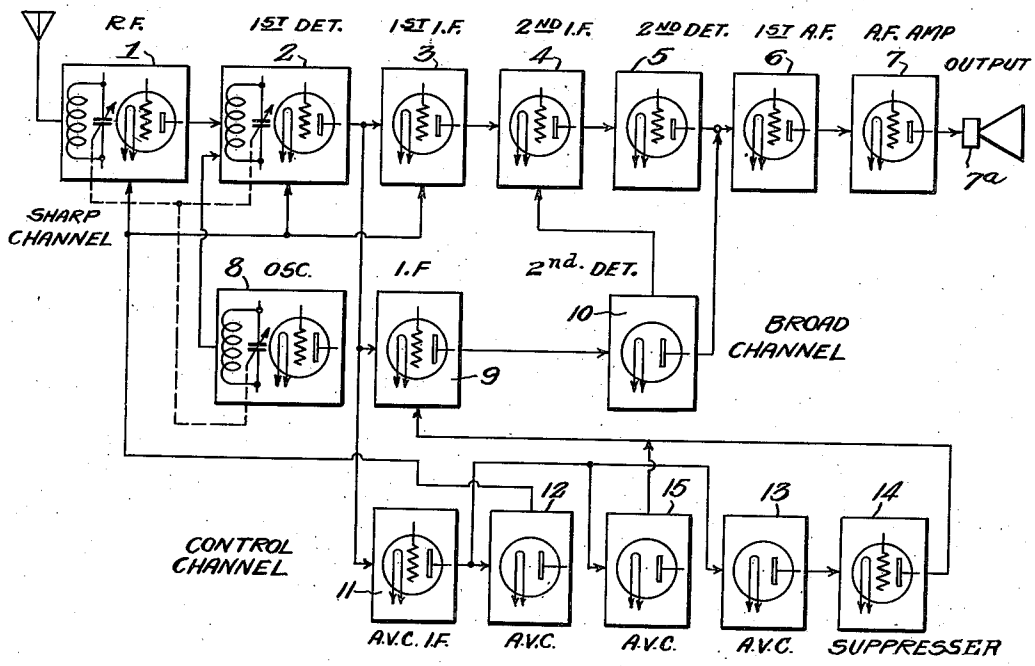


Fig. 3.

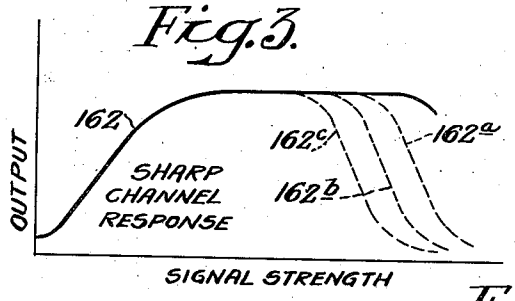


Fig. 4.

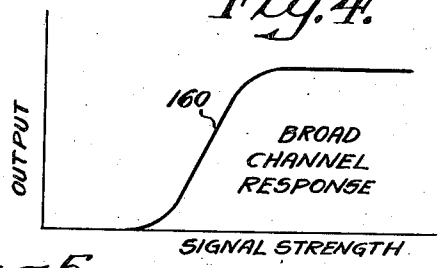
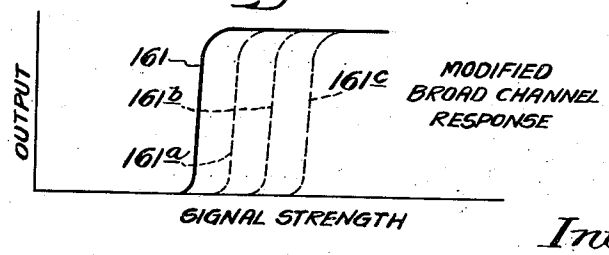


Fig. 5.



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HIGH FIDELITY RADIO RECEIVER

Filed Aug. 29, 1936 2 Sheets-Sheet 2

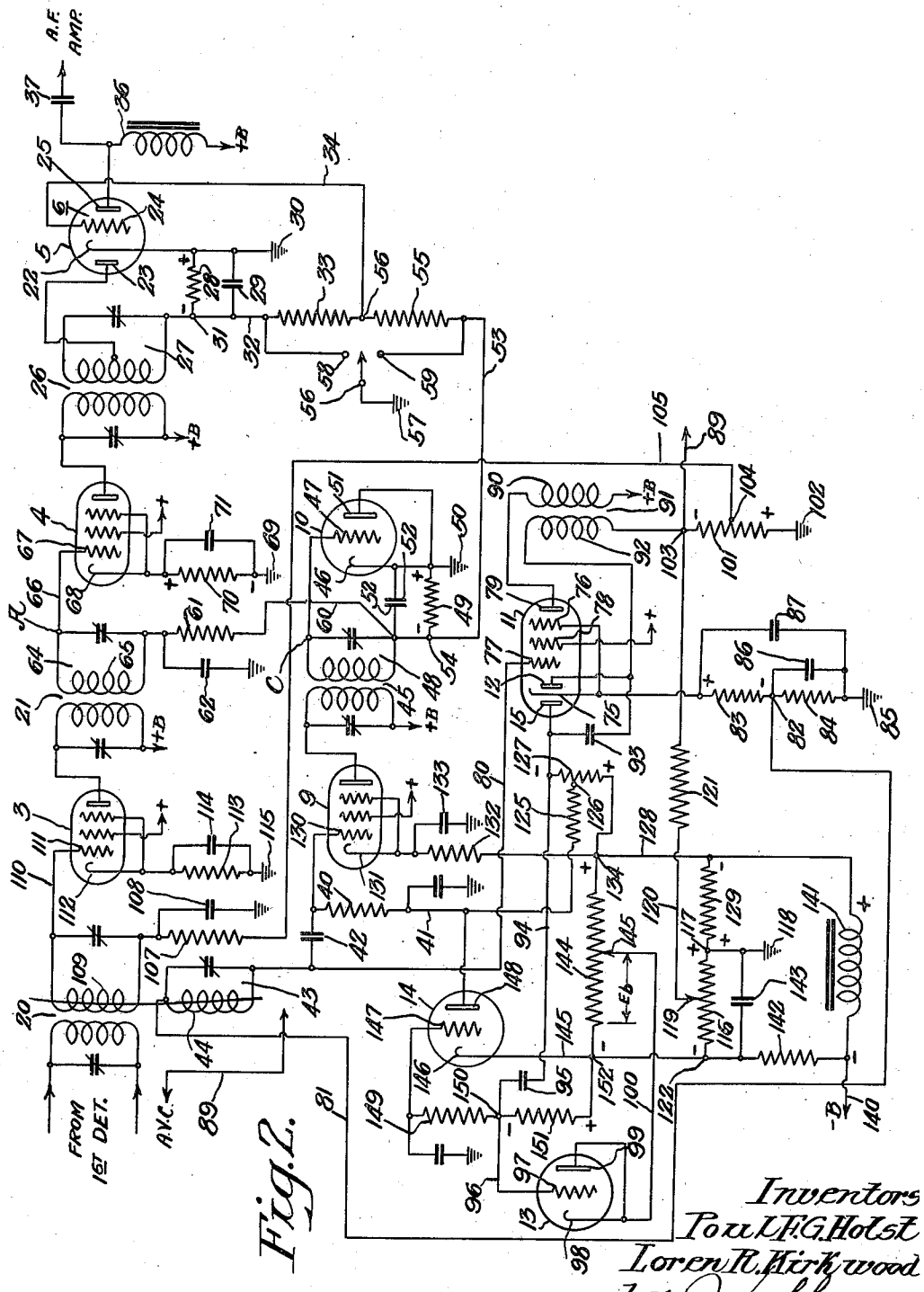


Fig. 2.

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UNITED STATES PATENT OFFICE

2,141,391

HIGH FIDELITY RADIO RECEIVER

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Application August 29, 1936, Serial No. 98,443

13 Claims. (Cl. 250—20)

The present invention relates to high fidelity radio receivers of the type having variable selectivity control means whereby the audio frequency response therefrom may be extended in range in response to an increase in the strength of a received carrier wave.

An object of the present invention is to provide an improved high fidelity radio receiving system having an audio frequency amplifier which is automatically controlled to receive signals through two receiving channels having differing degrees of selectivity, or either of said channels selectively, and an improved control system for a multiple channel receiving system of that character.

It is also a further object of the present invention to provide an improved automatic volume control and suppression system for a radio receiver in conjunction with selectivity control means, whereby the receiver is responsive to relatively strong modulated carrier waves with an extended audio frequency range of response.

It is a still further object of the present invention to provide a superheterodyne receiver having a plurality of intermediate frequency amplifying channels terminating in a common audio frequency amplifier, with an improved control means therefor.

It may be considered as a further object of the invention, also, to provide a superheterodyne radio receiving system having two intermediate frequency amplifier channels of differing selectivity and gain, and automatic means responsive to carrier wave strength for passing signals through either of said channels in accordance with the carrier wave strength.

It is also an object of the invention, to provide a radio receiver with automatic variable selectivity control means at a moderate cost comparable with the results obtainable, and an improved and effective sensitivity control means therefor.

Other objects and features of the invention will be apparent from the following description when considered in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the drawings, Figure 1 is a diagrammatic representation of a radio receiving system embodying the invention and showing the relation of the various amplifier stages and control means thereof.

Figure 2 is a schematic circuit diagram of a portion of the system of Figure 1 showing the circuits in detail, and

Figures 3, 4 and 5 are curves showing various operating characteristics of the system of Figures 1 and 2.

Referring to Fig. 1, a radio receiving system is shown comprising a sharp channel and a broad channel both of which are jointly controlled by a control channel as designated on the drawings. The main receiving channel comprises a radio frequency amplifier 1, coupled to a first detector 2 which supplies intermediate frequency signals to first and second stage intermediate frequency amplifiers, 3 and 4 respectively. The latter is followed in the receiving channel by a second detector 5, and a suitable audio frequency amplifier comprising first and second stages 6 and 7 respectively. A loud speaker or suitable output device is provided as indicated at 7a. An oscillator 8 is connected with the first detector to change received signals to the desired intermediate frequency.

The main signal channel, above described, is relatively sharply tuned to respond to relatively weak signals with a high degree of selectivity in the intermediate frequency amplifier stages 3 and 4 and the second detector 5.

A broadly tuned intermediate frequency amplifier and detector are also provided as a second signal channel in the receiver, and comprises an amplifier stage 9 and a second detector 10 coupled to the output circuit of the first detector. The second detector 10 is arranged to apply rectified signals to the audio frequency amplifier and a control potential to the second intermediate frequency amplifier stage, as indicated by the schematic circuit connections.

A further connection is made with the first detector output circuit for the control channel comprising an intermediate frequency amplifier stage 11 to which is coupled automatic volume control means 12, 13 and 15 in parallel, the automatic volume control means 13 also being connected with a suppresser stage 14.

The suppresser stage 14 is connected with the intermediate frequency amplifier stage 9 of the broad channel and also the automatic volume control means 15 is connected to the same stage for joint control of the broad channel I. F. amplifier.

The automatic volume control means 12 is arranged to control the gain in the radio frequency first detector and the first intermediate frequency amplifier stages of the sharp channel as indicated.

The operation of the system is such that for weak carrier waves, the main sharp signal channel is utilized to apply the signal output to the audio frequency amplifier and loud speaker while the broad channel is suppressed and inoperative,

and as the strength of a received carrier wave increases or a strong carrier wave is received, the sharp channel comprising the intermediate frequency amplifiers 3 and 4 and the second detector 5 is gradually cut off and the broad channel, comprising the intermediate frequency amplifier 9 and the second detector 10 is placed in operation.

In the first instance, the automatic volume control potentials are provided by the device 12 for the sharp channel, while in the second instance the automatic volume control potentials are supplied by the device 15 to the I. F. amplifier 9.

It will thus be seen that there is provided in the receiver, a modulated carrier wave or intermediate frequency amplifier having an amplifying and detecting channel providing a high degree of selectivity and a corresponding lesser degree of fidelity, and a broadly responsive intermediate frequency amplifier channel providing a high degree of fidelity. The control channel, also operating in parallel with the first two channels at the same intermediate frequency, is arranged for differentially controlling the first two channels, that is, to control the change over operation as above described, from one channel to the other through a series of automatic volume control and suppressor means provided with a common intermediate frequency amplifier whereby effective control potentials are available. The operation of the system, and the sensitivity control means provided in conjunction with the control channel, will further be understood by reference to Fig. 2 wherein the circuit details are shown for the three channels in the intermediate frequency amplifier and the first stage of the audio frequency amplifier, which operates in conjunction therewith.

Referring now to Fig. 2, wherein the like reference numerals are applied to the same amplifier and control stages as in Fig. 1, the intermediate frequency output from the first detector is applied to the first intermediate frequency amplifier tube 3 through a suitable tuned intermediate frequency input transformer 20. The tube 3 is coupled through a second intermediate frequency coupling transformer 21, to the second intermediate frequency amplifier 4. The second stage intermediate frequency amplifier is coupled to a second detector 5. The detector is of the diode rectifier type having a cathode 22, an anode 23, and further includes amplifier elements comprising the common cathode, a control grid 24 and an output anode 25.

The coupling between the intermediate frequency amplifier 4 and the detector 5 is provided by a tuned intermediate frequency output coupling transformer 26 providing a tuned secondary circuit 27 which is connected between the diode anode 23 and the cathode 22 through a diode output resistor 28. The latter is provided with a suitable intermediate frequency bypass capacitor 29.

The cathode is connected to ground or the common circuit return system of the receiver as indicated at 30, while the negative terminal 31 of the output resistor 28 is connected through an output lead 32, a coupling resistor 33, and a grid lead 34, with the control grid 24.

The audio frequency potentials established across the diode output resistor 28 are thereby applied to the control grid 24 and are suitably amplified in the amplifier section thereof comprising the cathode 22, the control grid 24 and the main output anode 25. The latter is coupled to the audio frequency amplifier through an output coupling impedance 36 and a coupling capacitor 37. With this arrangement, the detector and first audio frequency amplifier are combined in one device although it should be understood that they may be provided in separate stages as schematically represented in Fig. 1. Accordingly, the first audio frequency amplifier is designated in the device 5 by the reference numeral 6 as used in Fig. 1.

The intermediate frequency coupling devices 20, 21 and 26 represent the usual selective intermediate frequency coupling devices. Such coupling devices are represented in the present example, by transformers having tuned primary and secondary windings suitably coupled to provide a predetermined high degree of selectivity without appreciably attenuating the desired signal wave side bands.

The broad channel, however, is more fully responsive to the carrier wave and side bands without appreciable attenuation, to permit audio frequency fidelity substantially to the limit of a desired band such as to 8 kilocycles, for example.

In this channel, the first stage intermediate frequency amplifier 9 is provided with a grid coupling resistor 40 connected with the grid potential supply lead 41 and through a coupling capacitor 42 with a broadly tuned intermediate frequency input circuit 43 which is coupled inductively as indicated, with the intermediate frequency input transformer 20 through a coupling winding 44. Any other suitable coupling means for the device 9 may be employed in conjunction with the main signal channel from the first detector.

The amplifier device 9 is coupled on its output side, through a broadly tuned intermediate frequency coupling transformer 45 with the diode second detector 10 in the broad channel. This comprises a rectifier device having a cathode 46 and an anode electrode 47 connected with the tuned output circuit 48 of the transformer 45 through a diode output resistor indicated at 49. In this circuit, the cathode 46 is also connected to ground or the common chassis return circuit, as indicated at 50. In the present example a triode device is utilized as a rectifier, the anode 47 being a normal grid electrode and the main anode 51 being connected to the cathode 46. A suitable intermediate frequency bypass capacitor 52 is provided across the diode output resistor 49.

The detector 10 is connected, in with the detector 5, to the first audio frequency amplifier stage 6, through a similar coupling arrangement as provided for the detector 5. This comprises an audio frequency output lead 53 connected with the negative terminal 54 of the diode output resistor 49 and connected further through a high resistance element 55 corresponding to the resistor 33, to the lead 34 at a junction point 56 between the two resistors.

With this arrangement it will be seen that modulated signals received from the first detector, may be amplified through either or both of the amplifying channels, and after being rectified in either or both of the detectors 5 and 10, the audio frequency component is applied through the output leads 32 and 53 and the resistance elements 33 and 55 to the grid of the first audio frequency amplifier 6.

The latter grid may also receive biasing potential from both circuits with the signal potentials therefrom, whereby the sharp channel may be effective to provide a normal audio frequency response, or the higher fidelity response may be effected through the more broadly tuned chan-

nel, without changing any of the circuit connections.

The series resistors 33 and 55 between the output resistors 28 and 49 are preferably relatively high in value whereby the two diode circuits are substantially de-coupled. This is preferable in order to keep the interference between the two channels relatively low and in order to do this, the ratio of the resistors 33 or 55 to the resistors 28 or 49 should be kept as large as practically possible.

Either of the two signal channels may separately be connected with the audio frequency amplifier by operation of a simple two-point switch having a movable contact 56 connected to ground 57 and having two contact points 58 and 59 connected with the audio frequency output leads 32 and 53, respectively, for the two audio frequency channels.

Closure of the switch arm 56 with the contact 58 serves to ground the output lead 32 and cuts off the audio frequency output from the sharp channel, whereby signals are transmitted from the broad channel through the lead 53 and the lead 34 from the tap 56 between the two resistor sections 33 and 55, thereby providing, in effect, a tap midway of a resistor comprising the two sections 33 and 55. One-half of the available output potential on the lead 53 is applied to the lead 34.

In a similar manner, when the switch arm 56 is connected with the contact 59, the lead 53 is grounded, whereby signals are taken from the sharp channel through the lead 32 and the lead 34 from the tap 56, which again serves as a mid-tap on the resistor 33—55.

Through the medium of a simple two-point switch having a mid position, signals may be taken from either or both signal channels and applied to a common audio frequency amplifier grid circuit. The switching arrangement is further simplified by the fact that no additional biasing potential is necessary other than that provided by the incoming signal, as derived from the diode output resistor or resistors.

This channel mixing system is shown, described and claimed in our Patent No. 2,127,816, issued August 23, 1938, for Multichannel radio receiving systems, and assigned to the same assignee as this application. Accordingly, further description of this portion of the system is believed to be unnecessary.

Gain or volume control potential for suppression in the sharp channel and, in the present example, for the second intermediate frequency amplifier stage 4, is derived from the second detector of the broad channel. A volume control lead 60 for the stage 4 which includes a filter comprising a series resistor 61 and bypass capacitor 62, is connected with the negative output terminal of the diode output resistor 49. The lead 60 is connected through the tuned input circuit 64 for the tube 4 comprising an inductor 65 and the grid lead 66, to the control grid 67. The cathode 68 is connected to ground 69 through a self-bias resistor 70 provided with a bypass capacitor 71.

This arrangement serves to place a fixed biasing potential of predetermined value on the grid 67, from the self-bias source 70, and an additional biasing potential, in the presence of signals, as derived from the detector output resistor 49. This operates to reduce the gain of the stage 4 and thereby to regulate the volume or signal level in the sharp channel. The potential derived from this control source is, on strong signals, sufficient to fully suppress the sharp channel.

Automatic volume control potentials for the radio frequency amplifier, as diagrammatically indicated in Fig. 1, are derived from the automatic volume control rectifier 12, which is preceded by an automatic volume control intermediate frequency amplifier 11. In the present example, the intermediate frequency amplifier 11 is a double diode pentode device containing the diode electrodes 12 and 15 for the diode devices designated in Fig. 1 by the same numerals, and having a common cathode 75 connected with a suppressor grid 76 and further having a control grid 77, a screen grid 78 and an output anode electrode 79.

Signals at intermediate frequency are applied to the control grid 77 through a lead 80 which is coupled with the same input circuit 43 as is provided for the amplifier device 9 in the broad channel. In this case, the lead 80 is connected directly through the tuning inductance 44 of the circuit 43 and receives biasing potential therethrough from a biasing potential supply lead 81 which is connected with a tap point 82 on a series resistor comprising two sections 83 and 84 between ground 85 and the cathode 75 of the automatic volume control amplifier 11. The resistors 83 and 84 are provided with suitable bypass capacitors 86, 87 for intermediate frequency currents.

The initial biasing potential applied to the grid 77 with respect to the cathode 75 is a normally self-biasing potential obtained by the drop in the section 83.

The output anode 79 of the amplifier 11 is connected to the primary winding 90 of a natural period intermediate frequency amplifier coupling transformer 91, the secondary 92 of which is connected at one end with the diode anode 12 and through a coupling capacitor 93 with the diode anode 15, and also through the coupling capacitor 93, a lead 94, a coupling capacitor 95 and a lead 96 to the anode electrode 97 of the rectifier 13 which, in the present example, is a triode device. The grid of the latter serves as the anode electrode 97, and the anode 99 is interconnected with the cathode and an output lead 100. The remainder of the circuit for the device 13 will hereinafter be described.

It will be seen that the intermediate frequency signal voltage amplified in the device 11, is applied through the coupling transformer 91 to three diode rectifier devices comprising the anodes 12, 15 and 97. When the signal voltage is of sufficient positive value to overcome the voltage existing on the cathode 75 the intermediate frequency signals are rectified and the output therefrom is applied to an output resistor 101 through a series circuit which may be traced from the cathode 75, through the resistors 83 and 84, to ground 85 and a ground 102 for the resistor 101, thence through the resistor 101 to a terminal 103, and from the terminal 103 to the secondary 92 and the anode 12.

The rectified signal current is of relatively low value with respect to the anode current of the device 11 flowing in the resistors 83 and 84, and therefore does not serve to change the potential to any appreciable degree. However, in the output resistor 101, a potential having a polarity as indicated is set up and may be derived from the terminal 103 for negative biasing purposes and also from a suitable tap 104. The latter is connected through a bias supply lead 105 with the first intermediate frequency amplifier 3. The connection includes a filter comprising a series

resistor 107 and bypass capacitor 108, the secondary 109 of the transformer 20, a grid lead 110 and the control grid 111 of the amplifier 3. The automatic volume control potentials for the other input circuits of the receiver are taken from the other negative terminal 103 on the resistor 101 through a lead 89—89 which is broken to simplify the circuit diagram.

The cathode 112 of the intermediate frequency amplifier 3 is provided with a self-bias resistor 113 and suitable bypass capacitor 114 with a ground connection as indicated at 115 to establish on the grid 112 an initial negative bias for normal or full amplification of received signals.

With this arrangement, the preceding signal input stages and circuits of the receiving system, represented by the first intermediate frequency amplifier, may receive additional automatic volume control or biasing potentials from the output resistor 101 under control of the diode 12.

It has been found that in connection with the main gain controlling circuits of the receiving system, such as above described, there may also be arranged a manually variable sensitivity or volume control means for the receiving system, without the addition of complicated circuits and with only a limited number of additional control elements.

It has been seen that the present automatic gain control system involves the operation of the diode rectifier 12 to provide with increasing carrier wave or signal strength, an increasing negative potential across the diode output resistor 101 and a corresponding increasing negative potential with respect to ground at the point or terminal 103. A portion of this voltage is utilized for automatic volume control purposes through the lead 105 on first I. F. amplifier 3, and the full voltage is used for automatic volume control purposes on the R. F. amplifier and first detector, through the lead 89—89.

If, now, a potential drop is provided in a potentiometer device 116 having a polarity as indicated, with the positive end thereof 117 connected to ground as indicated at 118, the potentiometer contact 119 may be connected through a lead 120 and a series potential drop regulating resistor 121 with the terminal 103, to supply an adjustable potential to the automatic volume control resistor 101.

If the resistor 121 has a relatively high resistance with respect to the output resistor 101 and the contact 119 is moved to the terminal 117, the operation of the automatic volume control means is the same as previously described and the only delay on the diode 12 will be that set up by the drop in the self-bias resistor sections 83 and 84.

However, if the contact 119 is moved along the source 116 to establish between ground and the terminal 103 a negative potential, this will appear as a delay potential on the anode 12 and the potential will be applied through the resistor 121 across the diode output resistor 101, and as the contact is moved toward a negative terminal indicated at 122, the full potential available will be applied across the output resistor 101, and the negative bias applied to the diode anode 12 will be the potential derived from the resistor 116 as proportioned between the resistors 121 and 101.

In the absence of a received signal, it will be seen that by the adjustment of the contact 119, the sensitivity of the input circuits of the receiver may be limited to a desired degree in exactly the same manner as if a signal were limited by reason of operation of the automatic volume control rectifier 12, since the negative potentials available on the terminals 103 will be in the same proportion as if they were provided by a rectified signal on the anode 12.

However, this portion of the present system, comprising the sensitivity and noise suppression control of the diode 12, as above described briefly, is more fully shown and described and is claimed in our copending application, Serial No. 98,746, filed August 31, 1936, for Noise suppresser systems, and is assigned to the same assignee as this application. Accordingly, this portion of the system will not further be described.

It should be noted that at the same time the sensitivity is reduced, a further delay potential is impressed upon the diode anode 12, causing the diode to become inoperative until the signal amplitude is such that it corresponds to the gain predetermined by the adjustment of the sensitivity control contact 119. For this and higher signal strengths, the automatic volume control means, as described, functions in the same manner as it would if the sensitivity control were set for maximum sensitivity at the contact point 117.

The broad signal amplifying channel comprising the intermediate frequency amplifier 9 and the detector 10 is similar to the sharp channel except that the gain is preferably lower as indicated by the lesser number of stages in the present example, because of the fact that the broad channel is used only in response to relatively strong carrier waves. Therefore, it is necessary that the automatic volume control means which controls the broad channel be provided with a greater degree of delay than the sharp channel in order to obtain substantially constant audio frequency output on the first audio frequency amplifier as is desired, regardless of the signal strength.

The operation of the system is such that as the carrier wave strength varies on the receiving system, a substantially constant audio frequency potential is delivered to the first audio frequency input grid 6 for the same degrees of modulation. This is accomplished by utilizing an independent diode 15 for the automatic volume potential supply for the broad channel intermediate frequency amplifier, and by returning the diode output resistor circuit to a point on a potential supply system at a point more negative than ground, to which point the cathode or cathodes of the broad intermediate frequency amplifier channel are returned.

For the above control arrangement of the broad channel, the grid bias supply lead 41 of the amplifier 9 is connected through a potential drop producing resistor 125 with a tap 126 on a diode output resistor 127 connected in circuit with the diode anode 15 and the cathode 75. The connection is completed through a lead 128 and a source of negative biasing potential 129 to ground 118 and the ground 85, returning through the resistors 83 and 84 to the cathode 75.

Intermediate frequency signals supplied by the transformer 91 from the amplifier 11 are applied to the diode 15 through the coupling capacitor 93, as described, and a portion of the negative potential developed across the output resistor 127 is applied to the control grid 130 of the amplifier 9, through the grid resistor 40, the supply lead 41 and the series resistor 125, from the tap 126. The cathode of the device 9 designated at 131, is connected through a self-bias resistor 132, having a bypass capacitor 133, with a terminal 134 in

connection with the lead 128, whereby the potential applied between the grid 130 and the cathode 131 may be provided by the self-bias resistor 132 when the received signal strength is not sufficient to overcome the delay on the rectifier anode 15, from the sources 129 and 83—84, and as the signal strength increases to a value above the delay potential, the potential derived across the resistor 127 is added thereto to provide an increasing negative bias on the grid 130 with respect to the cathode, thereby to reduce the gain in the broad channel, for automatic volume control purposes.

The diode 15, however, is not permitted to come into action until a predetermined signal strength is available, dependent upon the additional delay potential provided by the source 129 which is in series between the anode 15 and the cathode 75.

It will be seen that the peak amplitude of the signal delivered to the diode anode 15 must have a positive value greater than the negative potential available across the resistor 129 and the self-bias resistors 83 and 84, and the value of the delay potential may be adjusted to any suitable value, whereby the signal strength or gain through the broad channel may be reduced only after a relatively high signal amplitude or carrier wave strength is applied to the receiving system.

Meantime, through the automatic volume control diode 12, with less delay, the sharp channel and the input circuits of the receiver may be controlled by the potentials supplied from the diode output resistor 101. Also, independently of the other automatic volume control means, the broad channel detector 10 serves to control the gain of the intermediate frequency amplifier stage 4, thereby reducing the gain in the sharp channel with increased signal on the broad channel, thereby providing a proper balance in output to deliver to the first audio frequency amplifier grid 6 substantially a constant signal, as the transition is made from sharp channel to broad channel receiving conditions.

The biasing potential source provided by the resistor 116, providing a negative potential supply for the contact 119 and the automatic volume control diode 12, for sensitivity control of the receiver, and additional delay on the diode anode 12, and the potential source provided by the resistor 129 for the diode anode 15 may be connected in any suitable manner to provide negative delay potentials with respect to ground 118.

In the present example, resistors are connected in the negative power supply lead 140 for the receiver, which is connected with the chassis or ground 118 through a choke coil or field winding 141 and the resistor 129, in series.

The resistor or potentiometer 116 is then connected between ground and the negative terminal of the choke coil 141 through a filter resistor 142 provided with a bypass capacitor 143, whereby the resistors 142 and the potentiometer 116 are connected in series as a parallel path across the choke coil 141 and the resistor 129. This arrangement provides two separate negative bias potential supply elements in the negative lead of the power supply circuit for the receiver, and is thereby adapted for the circuits above described to supply biasing potentials thereto.

The difference between the potential drop through the resistor 129 and through the resistor 116 is also applied across a potentiometer resistor 144 which is connected in parallel with said resistors between the terminal 134 on the lead 128 and a cathode lead 145 for the suppressor tube 14 which comprises a cathode 146, a control grid 147 and an anode 148.

The grid of the suppressor tube 147 is connected through a grid resistor 149 with the negative terminal 150 of a diode output resistor 151 for the diode rectifier 13. The diode circuit includes the anode electrode 97, the lead 96, the output resistor 151, and a terminal 152 in connection with the cathode lead 145 and the resistor 144, thence through the resistor 144, and through a movable tap 145 which is connected with the lead 100 for the cathode 98. This circuit arrangement provides a variable negative delay potential on the anode electrode 97 with respect to the cathode 98.

With no signals received through the input circuit 43 and the amplifier 11, the signals applied to the diode anode 97 are zero, with the result that there is no biasing potential applied to the control grid 147, with respect to the cathode 146. The impedance of the suppressor tube 14 is thereby relatively low and the potential existing across the terminals of the potential supply source 144 causes current to flow through the resistor 127 and the resistor 125, to apply a cut off potential to the amplifier tube 9 in the broad channel, thereby, in the absence of received signals, serving to cut off the broad channel response.

If the suppressor tube 14 is cut off by applying a strong negative biasing potential between the control grid 147 and the cathode 146, the automatic volume control system in connection with the diode 15 will function to control the amplifier 9 in a normal manner, as hereinbefore described.

For this purpose, the diode rectifier 13 is provided with a variable delay potential E_b between the potentiometer contact 145 and the terminal 152. This potential is adjusted to a value such that when the carrier wave or intermediate frequency signal strength increases, no current is drawn through the diode output resistor 151 until a predetermined high value of the carrier strength is obtained. Up to this point, the broad intermediate frequency amplifier channel remains cut off.

Beyond that point, when the signal reaches a higher magnitude, the peak intermediate frequency potential is applied from the circuit lead 94 through the capacitor 95 to the diode 13, producing a negative biasing potential across the output resistor 151 and on the control grid 147 of the suppressor tube 14 to cut off the latter tube and to permit the automatic volume control potential developed across the bias resistor 127 to control the grid 130 of the amplifier tube 9. Thereafter, the broad channel is controlled by the automatic volume control means, comprising the diode anode 15.

By adjusting the contact 145 to vary the delay potential on the diode rectifier controlling the suppressor tube, a variable delay in the operation of the broad channel may be provided.

The operation of the system briefly is as follows and may be considered by referring to both Figs. 1 and 2:

A signal impressed upon the input circuit of the receiver is amplified in the radio frequency amplifier and is converted to a predetermined intermediate frequency by the oscillator and first detector and may then flow through three channels, comprising the main intermediate frequency channel, including the tubes 3, 4 and 5, the broad intermediate frequency amplifying channel including the tubes 9 and 10, and through a control channel comprising the amplifier 11 and the

diodes 12, 15 and 13, the latter controlling a suppressor tube 14.

The broad channel remains cut off, provided the signal is not strong enough to cut off the suppressor tube 14. The sharp intermediate frequency channel is controlled above a predetermined delay, by the diode 12, and upon increase of signal strength to the point where the suppressor cuts off, the radio frequency signal strength is maintained constant on the sharp detector, comprising the diode 23 in the tube 5.

Increasing the signal strength further causes the broad channel to operate and to amplify signals, and the voltage rectified by the detector 10 will begin to suppress the signals in the sharp channel by applying an automatic volume control potential to the second intermediate frequency amplifier tube 4. If the signal or carrier wave still further increases in strength, the sharp channel finally may become entirely cut off by action of the volume control potential derived from the detector 10 which is, therefore, effectively a suppresser tube for the sharp channel.

It is considered desirable, in order to provide proper selectivity for the system, that the broad channel may be entirely cut off in the presence of weak signals because even a small portion of the signal coming through the broad channel at that time would definitely cause the selectivity to be below the desired permissible value, in which case the signals are received entirely through the sharp channel.

The response of the broad channel without the suppressor may be represented by the curve shown in Fig. 4 at 160, and the addition of the suppressor modifies the action of the broad channel as represented by the curves 161a, 161b, and 161c, the cut off points being extended to operate in response to a stronger signal by adjustment of the contact 145 to apply a high delay potential to the diode rectifier which controls the suppressor tube. Thus, the advantage of providing a variable suppressor cut off is realized.

If now the direct current voltage created by the broad channel second detector 10 is applied as an automatic control voltage on the second intermediate frequency amplifier, as described, the overall response curve of voltages applied to the audio frequency amplifier represented by the curve 162 may be obtained and results from the smooth change-over of the audio frequency amplifier from the sharp channel detector output to the broad channel detector output under control of the broad channel detector 10.

If the suppressor control is adjusted to provide the operating curves 161a, 161b, or 161c, the signal output on the audio frequency amplifier may be reduced with further signal strength increase, as indicated.

The signals created in the two detectors 5 and 10 are mixed by means of the mixing circuit and if the preceding control circuits are adjusted as described, the signal output on the first audio frequency amplifier grid 6 may be substantially constant, although the selectivity of the receiving system may vary. It is evident that the signal or carrier wave strength at which the change-over takes place may be varied by changing the suppressor cut off in the broad channel and that the change-over from one channel to the other may be effected gradually by proper adjustment of the control contacts 145 and 119.

The system described has the advantage that more than one intermediate frequency channel is utilized to carry the modulated carrier wave or signal and the two channels are controlled simultaneously by a third control channel including a suppressor and separate automatic volume control means therefor, including a sensitivity control by which the initial sensitivity of the system may be adjusted, and may be operative to control the sensitivity up to a predetermined point at which the automatic volume control means begins to function.

The system further includes a control circuit which permits the change of operation from one channel to the other to be effected at a predetermined signal level and includes a diode rectifier circuit therefor and a mixing system for the two signal channels which requires no switching operation to change from one channel to the other in connection with a common audio frequency amplifier.

The last named circuit has the further advantage that the audio frequency amplifier is diode or signal biased by the signal from the diode second detectors in both channels, either jointly or separately, depending upon the operation of the system through the one or the other, or both intermediate frequency amplifying channels, thereby preventing overloading.

The use of a plurality of signal amplifying channels, such as three intermediate frequency amplifying channels in a radio receiving system, with one channel providing a control potential for the others, is shown, described and claimed in a copending application of Paul Weathers, for High fidelity receiving systems, filed August 29, 1936, Serial No. 98,435, and assigned to the same assignee as this application.

Accordingly, the use of three signal amplifying channels, per se, are not claimed herein, but in all other respects, the invention should be understood as being not limited to the specific receiving system shown, and only by the appended claims.

We claim as our invention:

1. In a radio receiving system having a pair of signal amplifying channels offering differing degrees of selectivity to received signals, the combination of demodulator means for each of said channels, means providing a gain controlling connection for deriving a gain controlling potential from only one of said demodulator means and applying said potential to the other of said signal amplifying channels to suppress the flow of signals therethrough in response to an increase in the strength of signals applied to said demodulator means, automatic volume control means comprising a diode rectifier connected with one of said channels to receive signals therefrom to be rectified and having an output resistor for rectified signals, means for applying automatic volume control potentials from said output resistor to said receiving system preceding said channels to reduce the gain therethrough in response to an increase in the amplitude of received signals, means for establishing on said output resistor a fixed biasing potential, and means for varying said potential, thereby to vary the gain of said receiving system independently of the automatic volume control means.

2. A radio receiving system comprising, in combination, signal receiving means, means providing a signal amplifying channel, means providing a second signal amplifying channel having a relatively broad frequency response characteristic and a control channel for said first and second named channels comprising an amplifier stage for said received signals and a plurality of rectifier devices connected with said amplifier stage to

receive the amplified signal output therefrom, means for controlling the gain of said first named signal amplifying channel inversely in response to variations in the strength of a received carrier wave, means for controlling the gain in the broadly responsive signal amplifying channel directly in response to variations in the strength of a received carrier wave, means for suppressing the flow of signals through said broadly responsive signal amplifying channel connected with another of said rectifying devices to receive rectified signal output potential therefrom, and means for applying a variable delay potential to said last named rectifier device, whereby said suppressor is rendered ineffective above a predetermined signal strength.

3. A radio receiver in accordance with claim 2 further characterized by the fact that means are provided for applying to each of said diode rectifier devices a predetermined differing delay potential, certain of said potentials being variable, whereby the response of said amplifying channel to the received signal may be controlled and the change from one amplifying channel to the other may be adjusted for a predetermined signal strength.

4. In a radio receiving system having three intermediate frequency amplifying channels, the combination of means in two of said channels providing differing frequency band width response and gain therein, and means in connection with the third amplifying channel for differentially controlling the signal amplifying operation of said two channels in response to variations in signal strength to bring one channel into operation and to cut off operation of the other channel, and means in connection with said third channel control means for adjusting a control potential therein whereby the signal strength for determining the change from one amplifying channel to the other may be adjusted.

5. In a radio receiving system having a plurality of signal amplifying channels, the combination therewith of a control channel including signal amplifying means and automatic volume control means for said first named amplifying channels, means for controlling said first named channels in response to signal variations whereby one of said channels at a time is effective to amplify signals, and means in said control channel for determining the point of change from one channel to the other and the signal amplitude required to effect such change.

6. In a superheterodyne radio receiver, the combination with a pair of intermediate frequency amplifier channels, one of which has a relatively broad and the other of which has a relatively sharp frequency response characteristic, of a third intermediate frequency amplifying channel including automatic volume control means for said receiving system, suppressor means for the relatively broad channel included in said channel, and suppressor means in the broad amplifying channel for controlling the relatively sharp amplifying channel whereby as the signal strength increases the relatively broad channel is effective to amplify said signals and the amplifying effect of the sharp channel is reduced, and means for controlling said suppressor means whereby they operate consecutively and in an opposite sense.

7. In a superheterodyne radio receiving system, the combination of an intermediate frequency amplifier providing a plurality of intermediate frequency amplifying channels of differing frequency band width and gain, means providing a separate control channel including an intermediate frequency amplifier device and a plurality of diode rectifier devices for amplified signals from said device, means responsive to received signals of predetermined amplitude connected with said control channel for suppressing the flow of signals through an intermediate frequency amplifying channel having a wide frequency band width, and means for gradually suppressing the flow of signals through another of said channels in response to the flow of received signals through said first named channel when receiving relatively strong signals.

8. In a radio receiving system, the combination as defined in claim 7 further characterized by the fact that means are provided for controlling the change from one intermediate frequency amplifying channel to another in response to variations in the strength of a received carrier wave, whereby the audio frequency output from said signal amplifying channels is substantially constant.

9. In a radio receiving system the combination of means providing a pair of signal amplifying channels one of said channels being more broadly responsive to received signals than the other of said channels, means responsive to signal strength variations for controlling the sensitivity of said channels in opposite sense to render the more broadly responsive channel effective to amplify signals only in response to signals of predetermined high amplitude, and means for limiting the more sharply responsive signal amplifying channel for amplifying signals of a lower amplitude, said signal responsive controlling means including an adjustable control element and a diode biased amplifier tube having an anode circuit connected with said more broadly responsive signal channel for adjustably controlling the point of changeover from signal reception in one channel to signal reception in the other channel.

10. In a radio receiving system the combination of a pair of parallel connected signal amplifying channels each comprising a gain controllable amplifier and one of said channels providing a higher degree of amplification and being more sharply responsive to received signals than the other of said channels, automatic volume control means including a diode signal rectifier connected with said sharply responsive channel amplifier for controlling the gain therethrough inversely in response to signal strength variations, a second diode automatic volume control means including a second diode rectifier connected with the more broadly responsive signal channel amplifier for controlling the gain therethrough inversely in response to signal strength variations and an electric discharge amplifier device having an anode circuit connected in common with said last named diode to apply a controlling potential to the more broadly responsive signal amplifier thereby normally to suppress signal flow therethrough, a third diode rectifier device connected with said electric discharge amplifier device to apply a biasing potential thereto in the presence of signals thereby to remove the suppression control from said more broadly responsive signal channel, and means for applying to said last named diode rectifier device an adjustable delay potential whereby said suppression is removed in response to signals of a predetermined amplitude.

11. A radio receiving system in accordance with claim 10 further characterized by the fact that the more broadly responsive signal amplifying

channel includes a fourth diode rectifier device providing a control potential responsive to signal strength variations following the removal of suppression from said channel, and means for applying said potential to an amplifier device in said more sharply responsive signal amplifying channel in a direction to cause the gain therethrough gradually to be reduced in response to increased signal strength through said broadly responsive signal channel thereby to suppress signals through said more sharply responsive signal amplifying channels.

12. In a radio receiving system the combination of means providing a plurality of parallel connected signal amplifying chanels one of which terminates in a plurality of diode rectifier devices each responsive to received signals and having separate output circuits, means for applying differing delay potentials to said rectifier devices thereby to control the point of response of said rectifier devices to received signals, means for applying a controlling potential responsive to signal strength variations from the output circuit of each of said diode rectifier devices to one of said signal amplifying channels, means providing a noise suppressor control for one of said signal amplifying channels having a control potential source responsive to signal strength variations in the other of said channels, means providing a second noise suppressor control system in connection with one of said first named diode rectifier devices for said last named signal amplifying channel, and means in said suppressor control system providing a variable delay potential for the diode rectifier device associated therewith whereby said last named signal amplifying channel is caused to be responsive to signals having a signal amplitude above a predetermined amplitude.

13. In a radio receiving system in accordance with claim 12, further characterized by the fact that said signal channels are terminated by diode rectifier devices and a resistor network providing a common output circuit with said diode rectifier devices connected substantially in parallel relation to each other thereby to provide signal output and biasing potentials for said output circuit and that the automatic volume control circuit for one of said diode rectifier devices connected with the more sharply responsive signal amplifying channel is provided with an adjustable source of biasing potential for the output circuit thereof whereby the sensitivity of the receiving system may be adjusted manually.

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