

June 8, 1937.

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2,083,232

AUTOMATIC SELECTIVITY CONTROL SYSTEM

Filed April 8, 1935

Fig. 1

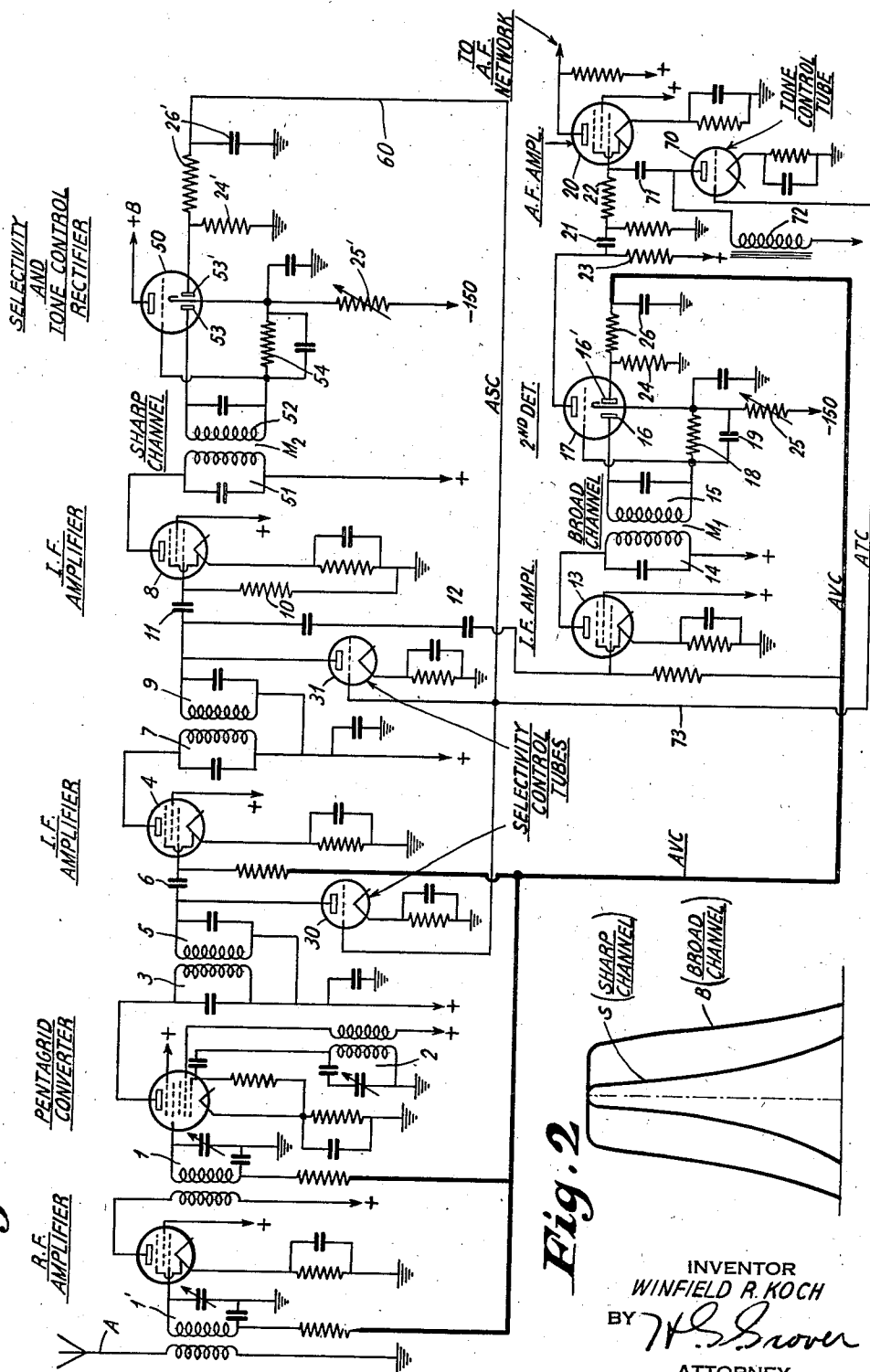
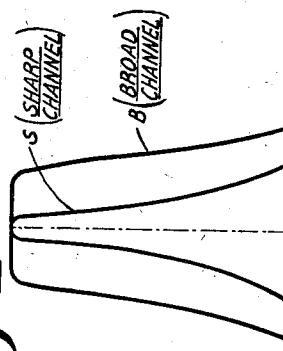


Fig. 2



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2,083,232

AUTOMATIC SELECTIVITY CONTROL SYSTEM

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Application April 8, 1935, Serial No. 15,168

11 Claims. (Cl. 250—20)

My present invention relates to automatic control circuits for regulating the selectivity of radio receivers, and more particularly to an improved type of control system for a radio broadcast receiver wherein the selectivity and tone of the receiver are automatically regulated.

One of the primary objects of the invention is to provide a receiver having dual control channels; one of the channels being sharp and feeding signals to a device which functions to regulate the radio frequency selectivity and the audio tonal characteristic of the receiver in response to received carrier amplitude variations, and the other channel being broad and feeding signals to an automatic radio frequency amplification control device.

Another important object of the invention may be said to reside in the provision of an improved selectivity control system for a radio receiver wherein the selectivity control network is fed with signals through a relatively sharp transmission channel whereby only by correct tuning will the full frequency range of the receiver be secured.

Still other objects of the invention are to improve generally the efficiency and reliability of automatic selectivity control systems for receivers, and more especially to provide automatic selectivity and/or tone control systems which are not only of improved operating characteristics, but are readily constructed and assembled in broadcast receivers.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated a circuit organization whereby my invention may be carried into effect.

In the drawing:—

Fig. 1 shows a receiving system embodying the invention,

Fig. 2 shows the resonance characteristics of the dual control channels of the receiver.

Referring now to the accompanying drawing, the latter shows in Fig. 1 a circuit diagram of a superheterodyne receiver embodying one form of the invention. The general networks of the receiver are conventional in nature, and comprise a signal collector A, such as a grounded antenna circuit, followed by a tunable radio frequency amplifier of well known type using a pentode tube. The amplifier output electrode is coupled to the

tunable signal input circuit 1 of the following pentagrid converter network. The latter uses a tube of the 6A7 type, and the circuits associated therewith are fully described and claimed by J. C. Smith in application Serial No. 654,421, filed January 31, 1933. It is sufficient for the purposes of this disclosure to point out that the numeral 2 designates the tunable local oscillator circuit of the converter network. The rotors of the variable tuning condensers of circuits 1 and 2, as well as the input circuit 1' of the radio amplifier, are uncontrolled, as is well known to those skilled in the art.

The circuit 3 in the plate lead of the pentagrid converter tube is fixedly tuned to the operating intermediate frequency, and the latter may be chosen from a frequency range of 75 to 500 k. c. The tube 4, also a pentode type tube, following the circuit 3 is an intermediate frequency amplifier. The signal grid thereof is coupled to the high alternating potential side of resonant circuit 5 by a condenser 6. The low alternating potential sides of circuits 3 and 5 are connected together. The resonant circuit 7 is in the plate circuit of the following intermediate amplifier tube 4, of the pentode type; the tuned input circuit 9 of tube 8 and the resonant output circuit 7 of tube 4 have their low alternating potential sides connected together. The cathode returns for circuits 5 and 9 to tubes 4 and 8 respectively are through the usual common voltage supply bleeder resistor (not shown).

The normal negative bias for amplifier 8 is secured by connecting the resistor 10 between the grid side of coupling condenser 11 and the grounded side of the grid bias resistor. The tuned circuits 3 and 5 are magnetically coupled. This is equally true of circuits 7 and 9. Each of these four circuits is tuned to the operating intermediate frequency.

The normal signal transmission path of the receiver may be traced from the circuit 9, through coupling condenser 12, to the signal grid electrode of the intermediate frequency pentode amplifier tube 13. The plate circuit of tube 13 includes the resonant circuit 14 tuned to the operating intermediate frequency. The second detector, or demodulator, is provided by a diode whose electrodes are the cathode and diode anode 16 of the duplex diode-triode tube 17, which may be of the well known 55 type. The resonant circuit 15 acts as the demodulator input circuit, and is connected, in series with load resistor 18, between the cathode of tube 17 and anode 16. The load resistor 18 is

by-passed for intermediate frequency currents by condenser 19.

The circuit 15 is tuned to the operating intermediate frequency, and is magnetically coupled to circuit 14. The coupling M_1 between circuits 14 and 15 is chosen so that a relatively broad resonance curve characteristic is obtained. The curve B in Fig. 2 denotes the type of characteristic desired for the network 14, 15. The control grid of tube 17 is connected to the anode side of resistor 18, while the plate of the tube 17 is coupled to an audio amplifier 20. The signal grid of the latter is connected to the plate of tube 17 through a series connection of a condenser 21 and resistor 22. The condenser side of resistor 22 is connected to the grounded side of the grid bias resistor through a leak resistor, and the plate circuit of tube 17 includes a coupling resistor 23. The plate circuit of audio amplifier 20 includes a load resistor, and the latter may be coupled to a subsequent audio network which may comprise one, or more, audio amplifiers followed by a reproducer.

The signal carrier amplitude at the circuit 15 is maintained substantially uniform over a wide range of signal carrier variation at the collector A by employing an AVC arrangement. The latter comprises the anode 16' of tube 17, co-operating with the cathode of the latter to provide a device of unidirectional conductivity. The anode 16' is grounded through resistor 24, while the variable resistor 25 is disposed in the cathode circuit of tube 17. A voltage point of about -150 volts is connected to the resistor 25, and the magnitude of the latter is adjusted to a point such that the cathode of tube 17 is positive with respect to the anode 16' for the space current flow which exists when receiving signals below a predetermined amplitude.

In the absence of received signals the control grid of tube 17 is at substantially cathode potential. The space current flow through resistor 25 is a maximum, since the resistor is in the plate to cathode current stream of tube 17. However, as the signal amplitude exceeds a predetermined level the voltage drop across resistor 18 increases and renders the grid of tube 17 increasingly negative. This results in a decrease in space current flow through resistor 25, and the voltage across the latter decreases until the cathode actually reverses in polarity with respect to the grounded anode 16'. When the cathode of tube 17 attains a negative potential with respect to the anode 16' there will be a flow of current through resistor 24. The voltage across resistor 24, of course, increases directly with the increase of carrier amplitude. Hence, it is only necessary to connect the grids of the tubes to be controlled in gain to the resistor 24 in order to secure the AVC action.

Thus, the signal control grid circuits of the radio frequency amplifier, converter and intermediate amplifiers 4 and 13 are connected through the heavy line leads designated "AVC" to the anode side of resistor 24. The resistor-condenser network 26 functions to suppress ripples in the bias voltage applied through the AVC leads; and the latter leads also include ripple suppression resistors at the points of connection to the aforesaid grid circuits. Each of the gain-regulated tubes includes the usual grid bias resistor network for establishing maximum gain, or sensitivity, condition in the absence of AVC action; the latter existing when signals be-

low a predetermined amplitude are received. As the signal amplitude increases the gain of each controlled tube decreases.

The receiving system further includes an automatic selectivity control arrangement. The latter utilizes electron discharge tubes 30 and 31; tube 30 having its plate to cathode impedance connected across the tuned circuit 5, while the plate to cathode impedance of tube 31 is shunted across the resonant circuit 9. The plates of tubes 30 and 31 are connected respectively to the high alternating voltage sides of circuits 5 and 9. The cathode of each of the selectivity control tubes is grounded through a grid bias resistor network. The plate impedances of tubes 30 and 31 are varied by varying the negative biases of the grids thereof; when the received signal amplitude is a minimum these biases are a minimum, and are produced by the bias resistors in the cathode circuits of tubes 30, 31. In such a case the shunting effect of tubes 30 and 31 on the networks 3-5 and 7-9 respectively is a maximum, and these networks have relatively sharp, single peak resonance curve characteristics. The characteristics are broadened double peaked curves when the shunting effects of tubes 30 and 31 are removed.

The shunting effect of each of tubes 30 and 31 is regulated by the networks now to be described. From the circuit 9 the intermediate frequency signal energy is transmitted through condenser 11 to amplifier 8. The latter amplifies the signal energy prior to rectification thereof, the rectification being performed to secure a variable negative bias for the tubes 30, 31. The amplified signal energy is impressed upon the diode rectifier electrodes of multiple duty tube 50 through a relatively sharp network comprising tuned circuits 51 and 52. The circuit 51 is disposed in the plate circuit of tube 8, while circuit 52 is connected between the anode 53 of tube 50 and the cathode thereof; the load resistor 54, properly by-passed, is included in the cathode tide of circuit 52. Each of the circuits 51 and 52 is tuned to the operating intermediate frequency, and they are magnetically coupled at M_2 so as to impart a sharp resonance curve characteristic to the signal channel feeding the diode anode 53.

The curve S in Fig. 2 illustrates the nature of the resonance characteristic of the sharp channel feeding tube 50; this curve is contrasted to curve B in the figure. The selectivity of circuits 3-5 and 7-9 depends on the fidelity desired for weak signals. M_2 is made as sharply selective as possible without making the receiver too difficult to tune, or keep in tune. In general, this should result in having M_2 somewhat sharper than circuits 3-5 and 7-9.

The circuit elements associated with tube 50 follow very closely those associated with tube 17. The anode 53', grounded through load resistor 24', is normally negative with respect to the voltage of the cathode of tube 50, and it will be observed that the cathode is connected by adjustable resistor 25' to a point which is about -150 volts with respect to ground. The control grid of tube 50 is connected to the anode side of resistor 54, and functions to reduce the space current flow through resistor 25' as the signal amplitude increases. When the space current flow through resistor 25' has been reduced to a point such that the cathode potential is negative with respect to the grounded anode 53', then current will flow through resistor 24'.

The anode side of the latter resistor 24' is connected by a lead 60 (denoted by the symbol "ASC" to show that it is the automatic selectivity control lead) to the control grids of tubes 30 and 31. The resistor-condenser filter 26' is used to prevent any pulsating current component from being transmitted through lead 60. It will now be seen that an increase in received signal amplitude above a desired value results in the impression of negative bias upon the grids of tubes 30 and 31 sufficient in magnitude to increase the plate impedances thereof to a point such that the networks 3-5 and 7-9 are broadened.

It will be noted that the tubes 50 and 17, although used for different purposes, function with their associated circuits in the same manner. Circuits of this type delay regulation of the gain of tubes to be controlled by a polarity reversal action. Such gain control circuits are disclosed and claimed in application Serial No. 640,946, filed Nov. 3, 1932, by L. E. Barton. Further, the selectivity control tubes and their functions have been disclosed and claimed in application Serial No. 588,909, filed January 26, 1932, by G. L. Beers, Patent No. 2,017,523, October 15, 1935.

In addition to the automatic regulation of the selectivity of the intermediate frequency circuits, the tube 50 acts to vary the conductivity of the tone control tube 70. The latter, as disclosed by G. L. Beers in U. S. P. 1,961,329 of June 5, 1934, has its plate connected to the grid side of resistor 22 by a condenser 71, and a choke coil 72 is disposed in the plate voltage supply line of the tube. The grid of the tone control tube is negatively biased by the usual grounded cathode bias resistor, and variable bias is applied to the grid by a lead 73 (also designated by the letters "ATC" to show that it is the automatic tone control lead). The lead 73 is connected through lead 60, to the anode side of resistor 24'. The function of the control tube 70 is to vary the flow of audio currents, through condenser 71, to ground. When the bias applied to the grid of tube 70 through lead 73 increases due to signal increase, then the control tube offers more impedance to audio currents flowing through condenser 71 to its plate thus causing less attenuation of the higher audio frequencies through resistor 22.

The operation of the various control networks (gain, selectivity and tone) will now be explained, special attention being directed to the effect of the sharp and broad channels (M_2 and M_1). It will be observed that a separate intermediate frequency channel is provided to the selectivity and tone control rectifier tube 50, and that this channel is maintained sharp so that no broadening of the selectivity curves can occur until the signal is tuned in to exactly the middle of the band. The amplifier 3 which feeds the sharp intermediate frequency channel is not regulated in bias by the AVC network. The significance of this resides in the fact that full selectivity control will be obtained when the signal is tuned in, and the AVC action, obtained through the AVC tube 17, is replaced by the control action obtained through the selectivity control tubes 30 and 31.

Assuming now that the receiver is being tuned to a desired carrier station, there will be a change in the plate to cathode impedances of tubes 30, 31, and 70 which are under the control of tube 50. The negative bias impressed on the grids of each of these three control tubes will increase

as the tuning of the receiver approaches the desired carrier frequency of the accepted band of the station desired to be received. The two selectivity control tubes and the tone control tube are operated by the signal through the sharp intermediate frequency channel M_2 . As the signal is tuned in to this channel the grids of the selectivity control tubes become more negative and the plate impedance of these tubes increases. The intermediate frequency transformers associated with these selectivity control tubes predominate in the double peaked effect as the shunting effect of these tubes is removed, and the selectivity curves of these transformers broadens out. The tone control tube offers more impedances to audio currents flowing through the condenser 71 to its plate as the negative grid bias thereof increases thereby causing less attenuation of the higher audio frequencies through the resistor 22.

Of course, when the receiver is mistuned the attenuation of the higher audio frequencies is a maximum because the control tube 70 offers minimum impedance to the flow of the higher audio currents through condenser 71. In this way for a received signal amplitude which is less than a predetermined value the audio output of the receiver will include a minimum of higher audio frequencies, and this means in turn that noise and other sounds in the higher audio frequency range will be effectively suppressed. Thus simultaneously with the control of the radio frequency selectivity of the receiver there is secured a higher audio frequency attenuation control which cooperates with the selectivity control to render reception of weak signals efficient.

The AVC system operates in the usual manner to maintain the signal amplitude at the input circuit 15 of the second detector substantially constant over a wide range of signal carrier variation at the collector A. The time constants of the AVC and ASC circuits should be such that the AVC works faster than the ASC so as to permit the AVC to take care of changes in amplification resulting from ASC action. The present system offers considerable improvement over prior methods of automatic selectivity control because the action here is retroactive. That is, when the signal is mistuned somewhat with the usual automatic selectivity control systems, the circuits will stay broad because enough signals will go through the intermediate frequency transformers to keep the selectivity control tubes functioning. On the other hand with the present type of sharp automatic selectivity control systems, only by accurate tuning will the full frequency range of the receiver be obtained.

Instead of separate tubes to secure selectivity control and volume control action ordinary diodes could be used in place of the duo-diode triodes shown. The diodes in such case could be combined with the preceding signal amplifier, and a diode pentode tube could be used for this purpose. However, by using the tubes 50 and 17 as shown, another desirable characteristic is obtained. By adjusting the resistor 25' in the cathode circuit of the selectivity control tube 50, the signal strength at which the receiver begins to broaden out can be adjusted easily. For example, as the signal increases the set can be made to broaden out at first. Then as the signal increases further, the AVC action will aid in volume controlling, and the set will not be broadened out to the full extent. On the other hand the adjustment to resistor 24' can be made so

that the AVC action will operate first as the signal increases, and then, after a certain signal strength, the selectivity control will start to broaden out the receiver.

This present arrangement permits a more flexible automatic selectivity control as well as one having superior operating characteristics. The variable resistor 25 can be employed for varying the degree of delay of the AVC action. The higher the voltage value of the negative end of resistors 25, 25' the greater will be the gain secured in the triode sections of tubes 17 and 50, and the more complete will the controls be. Of course, it will be understood that the specific type of selectivity, tone and gain control networks shown herein are simply illustrative in nature. Those skilled in the art are fully aware of networks adapted to perform similar functions, but which networks are specifically different from those shown in the present case.

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

What I claim is:

1. In combination, in a receiver, a source of high frequency energy including an amplifier for the energy, said amplifier being provided with an input circuit tuned to a desired signal frequency, means responsive to an increase of said energy above a predetermined intensity level for decreasing the selectivity of said amplifier input circuit, a transmission channel tuned to said desired frequency coupling said last means and the output of said amplifier, said channel having a relatively sharp resonance curve characteristic, a demodulator, a transmission channel coupling the demodulator input to the output of said amplifier, said last channel having a resonance curve characteristic which is substantially broader than the characteristic of said sharp channel, and means responsive to said intensity level increase for reducing the gain of said amplifier.

2. In combination, in a receiver, a source of high frequency energy including an amplifier for the energy, said amplifier being provided with an input circuit tuned to a desired frequency, means responsive to an increase of said energy above a predetermined intensity level for decreasing the selectivity of said amplifier input circuit, a transmission channel tuned to the desired frequency coupling said last means and the output of said amplifier, said channel having a relatively sharp resonance curve characteristic, a demodulator, a transmission channel tuned to said desired frequency coupling the demodulator input to the output of said amplifier, said last channel having a resonance curve characteristic which is substantially broader than the characteristic of said sharp channel, and means responsive to said intensity level increase for reducing the gain of said high frequency amplifier, an audio frequency utilization network coupled to the demodulator output, and means controlled by said selectivity control means for variably attenuating the higher audio frequencies in the demodulator output.

3. In combination, in a superheterodyne receiver, a source of intermediate frequency energy including an amplifier for the energy, said amplifier being provided with an input circuit tuned to the said intermediate frequency, means respon-

sive to an increase of said energy above a predetermined intensity level for decreasing the selectivity of said amplifier input circuit, an intermediate frequency transmission channel coupling said last means and the output of said amplifier, said channel having a relatively sharp resonance curve characteristic and being tuned to said intermediate frequency, a demodulator, an intermediate frequency transmission channel coupling the demodulator input to the output of said amplifier, said last channel having a resonance curve characteristic which is substantially broader than the characteristic of said sharp channel, and means responsive to said intensity level increase for reducing the gain of said intermediate frequency amplifier, said selectivity control means including an electron discharge tube having its plate to cathode impedance effectively in shunt with the tuned input circuit of said amplifier.

4. In combination, in a superheterodyne receiver, a source of intermediate frequency energy including an amplifier for the energy, said amplifier being provided with an input circuit tuned to the said intermediate frequency, means responsive to an increase of said energy above a predetermined intensity level for decreasing the selectivity of said amplifier input circuit, an intermediate frequency transmission channel coupling said last means and the output of said amplifier, said channel having a relatively sharp resonance curve characteristic and being tuned to said intermediate frequency, a demodulator, an intermediate frequency transmission channel coupling the demodulator input to the output of said amplifier, said last channel having a resonance curve characteristic which is substantially broader than the characteristic of said sharp channel, and means responsive to said intensity level increase for reducing the gain of said intermediate frequency amplifier, and an intermediate frequency amplifier coupling the output of said first amplifier and the input of said sharp transmission channel.

5. In combination, in a superheterodyne receiver, a source of intermediate frequency energy including an amplifier for the energy, said amplifier being provided with an input circuit tuned to the said intermediate frequency, means responsive to an increase of said energy above a predetermined intensity level for decreasing the selectivity of said amplifier input circuit, an intermediate frequency transmission channel coupling said last means and the output of said amplifier, said channel having a relatively sharp resonance curve characteristic and being tuned to said intermediate frequency, a demodulator, an intermediate frequency transmission channel coupling the demodulator input to the output of said amplifier, said last channel having a resonance curve characteristic which is substantially broader than the characteristic of said sharp channel, and means responsive to said intensity level increase for reducing the gain of said intermediate frequency amplifier, and independent intermediate frequency amplifiers arranged to feed intermediate frequency energy to said sharp and broad channels respectively.

6. In a receiver for radio frequency signals, including means for automatically adjusting amplification of the receiver with signal strength, and including means for automatically adjusting the frequency response characteristic of the receiver with signal strength, means for restricting the operation of the automatic adjustment of the frequency response characteristic to a small range

of mis-tuning of the receiver, means for restricting the operation of the amplification adjusting means to a relatively wider range of mis-tuning of the receiver, said small range being substantially independent of influence by the automatic adjustment of said frequency response characteristic.

7. A radio receiver comprising selectivity control means, means for controlling the sensitivity of the receiver, independent devices electrically associated with each of said means for automatically actuating them in response to amplitude variations in received signals, said devices having resonant input circuits tuned to an operating signal frequency, the input circuit of the device associated with the sensitivity control means having a relatively broader resonance curve characteristic than the input circuit of the other device.

8. A radio receiver comprising selectivity control means, audio frequency fidelity-control means, means including a signal-tuned input circuit having a relatively sharp resonance curve characteristic for automatically actuating said two control means, means including a signal-tuned input circuit responsive to changes in strength of incoming signals for automatically regulating the sensitivity of the receiver, said last means input circuit having a relatively broader resonance curve characteristic than said first characteristic.

9. A radio receiver comprising selectivity control means, means for controlling the sensitivity of the receiver, independent devices electrically associated with each of said means for automatically actuating them in response to amplitude

variations in received signals, said devices having resonant input circuits tuned to an operating signal frequency, the input circuit of the device associated with the sensitivity control means having a relatively broader resonance curve characteristic than the input circuit of the other device, and the time constants of the said two control means being so related that the sensitivity control means operates faster than the selectivity control means.

10. A radio receiving system comprising selectivity control means, audio frequency fidelity control means, means including a signal-tuned input circuit for simultaneously actuating said two control means, receiver sensitivity control means, and means including a signal-tuned input circuit independent of said actuating means for operating said sensitivity control means in response to amplitude variations in received signals, said two input circuits having substantially different resonance curve characteristics.

11. In a signal transmission system including a signal transmission network, a demodulator coupled to said network, and a demodulated signal utilization network, means for automatically varying the frequency response characteristic of the system in response to amplitude variations in signals, a network coupling said last means to the network preceding said demodulator, and said coupling network having a resonance curve characteristic which is substantially sharp with respect to the resonance curve characteristic of the said preceding network coupled to the demodulator.

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