

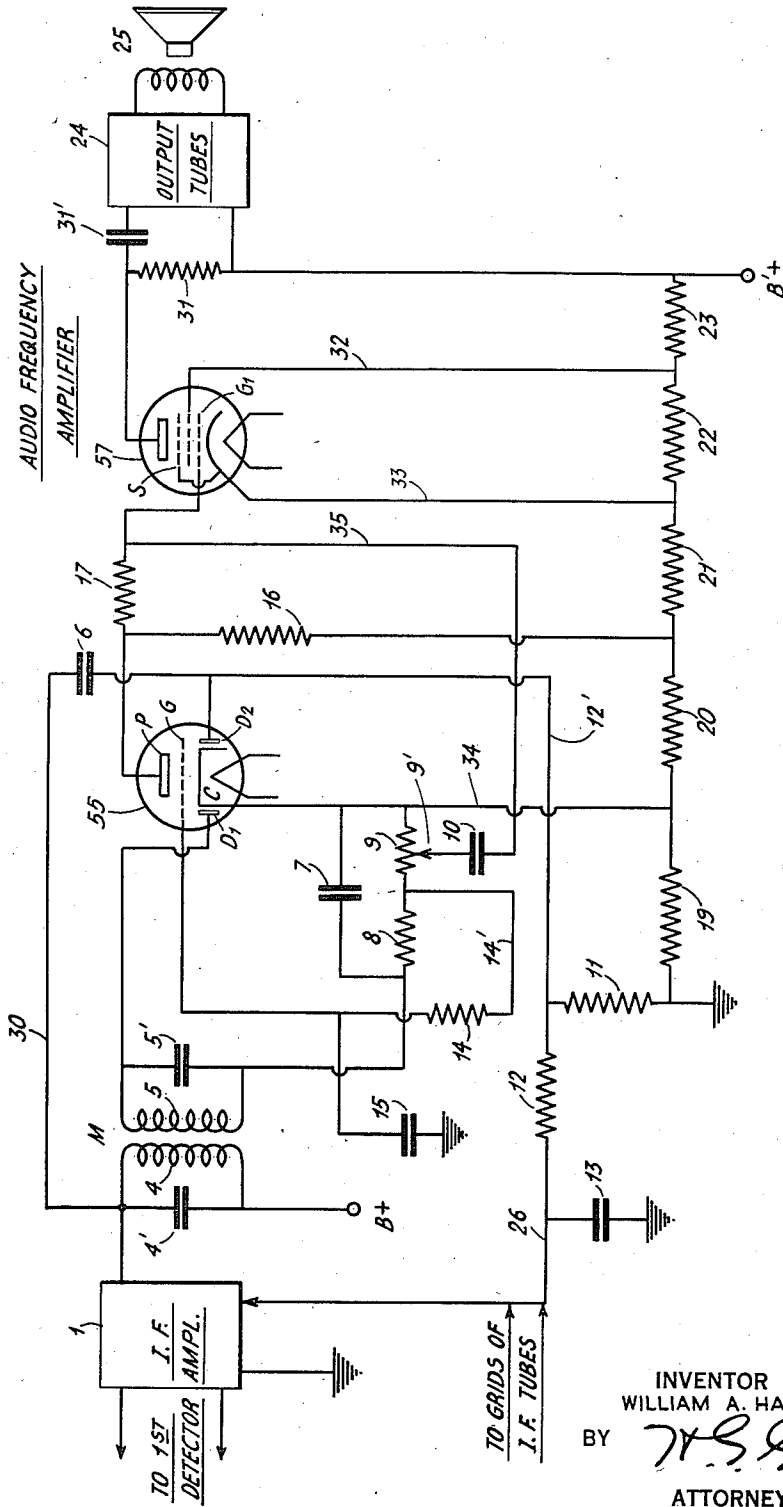
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SELECTIVE AUTOMATIC VOLUME CONTROL RECEIVER

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SELECTIVE AUTOMATIC VOLUME CONTROL
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My present invention relates to an improved radio receiver of the type including diode detection, automatic volume control and inter-channel noise suppression functions in a single stage of the receiver.

There has been disclosed by T. M. Shrader in application Serial No. 622,140, filed July 12, 1932, an electron discharge tube of the type known as the 55, the tube also being characterized by the expression "Duplex-diode triode". Briefly, the tube embodies a cathode, an anode, a grid, and a pair of auxiliary cold electrodes disposed on either side of the cathode out of the electron stream to the anode. This tube can be employed to provide diode detection, automatic volume control and a stage of amplification in a single stage of a receiver. Realizing that in the absence of carrier voltage, circuit noises, atmospheric, and tube noises are apt to be quite noticeable in a receiver employing such a triple purpose stage, D. G. Burnside in application Serial No. 644,149, filed November 25, 1932, disclosed various arrangements for employing the duplex-diode triode tube with control of the amplification of noise in the absence of sufficient carrier voltage. In these arrangements signal, or carrier, voltage must be greater than a predetermined bias before the detector action comes into play. This prevents the detection and audio amplification of the noises, if the bias is adjusted to be just greater than the noise level.

To avoid certain undesirable effects arising during operation of the delayed detection circuits of Burnside, there has been disclosed by J. S. Starrett in application Serial No. 644,169, filed November 25, 1932, arrangements for the accomplishment of detection, automatic volume control and automatic suppression of inter-channel noise in a duplex-diode triode stage. In general, each circuit in the absence of a signal operates to suppress noise by the application of cut-off voltage to the grid of the first audio amplifier stage; the said grid is, in the absence of signal, biased to cut-off, but is automatically removed from cut-off when a signal is received.

The removal of the said grid from cut-off is arranged to be accomplished by the supply of a reverse voltage from the rectified current through a resistance in series with one of the sets of diode elements in the duplex-diode triode tube.

Now, the present invention relates to, and has as its main object, the provision of a circuit arrangement which may be used with the duplex-diode triode tube to accomplish detection, automatic volume control and inter-channel noise suppression, and additionally providing an apparent increase in selectivity.

Another important object of the present invention is to provide a radio receiver having a stage interposed between a stage of intermediate

frequency, or radio frequency, amplification and a stage of audio frequency amplification, the interposed stage including a duplex-diode triode tube which is connected to the preceding and succeeding stages so as to provide diode detection, automatic volume control of the preceding amplifier stage, and inter-channel noise suppression by control of the succeeding amplifier stage, the interposed stage being additionally arranged for apparently increasing the selectivity of the receiver.

Another object of the present invention is to provide a radio receiver of the type including automatic volume control and inter-channel noise suppression, the receiver including additional means for tuning the set more sharply, whereby in terms of dial operation, a station can be heard over a very small portion of the tuning scale, thereby tending to minimize error in adjustment of the tuning control to the peak of the resonance curve; thus resulting in less liability of distortion due to this cause.

Still another object of the present invention is to provide in combination with an intermediate frequency amplifier and an audio frequency amplifier, a diode detection stage simultaneously functioning as an automatic volume control means, the energy for the automatic volume control action being obtained from the primary circuit of the coupling network between the intermediate frequency amplifier and the diode detection stage, there being provided an additional arrangement between the audio frequency amplifier and said diode detection stage for substantially preventing interchannel noises.

Still other objects of the present invention are to improve generally the simplicity and efficiency of duplex-diode triode circuits providing simultaneous diode detection, automatic volume control and inter-channel noise suppression, and to particularly provide such a circuit arrangement which is not only reliable in operation, but highly selective.

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 diagrammatically one circuit arrangement whereby my invention may be carried into effect.

Referring to the accompanying drawing, wherein there is shown only the portions of a superheterodyne receiver necessary for a proper understanding of this invention, the intermediate frequency amplifier 1 is shown as having its input terminals arranged for connection to the usual first detector, it being clearly understood

that the receiver is supposed to embody an antenna, a radio frequency amplifier and a local oscillator, the latter two being connected to the first detector.

5 The details of construction of the amplifier 1 are not shown, since it is very well known that it may embody a plurality of stages, each including a tube, and that the amplification of each of such stages may be varied by varying
10 the grid potential with respect to the cathode potential.

The amplifier 1 is coupled, as at M, to the tube 55, the latter being of the duplex-diode triode type disclosed by the above T. M. Shrader. The tube is conventionally shown in the drawing, since it is fully disclosed and claimed in the above Shrader application. It is sufficient for the present to describe it as including a uni-
15 potential cathode C of the heater type, an anode P, and a grid G to provide a triode system. A pair of diode anodes D₁ and D₂ are disposed on either side of the cathode out of the electron flow to the grid G and anode P, thus providing a pair of diodes independent of the triode system except for the common cathode. In operation, the two diodes C—D₁ and C—D₂ and the triode C—G—P are independent, the cathode having one emitting surface for the diodes and another for the triode. This permits of flexibility
20 in circuit arrangement and design.

Thus, as clearly disclosed by the aforementioned Burnside application, the diodes of the 55 tube can perform at the same time the functions of detection and of automatic volume control
25 with sensitivity control and time delay confined to the volume control circuit; while at the same time the triode may be used as an amplifier under its own optimum conditions. The present invention relates to an improvement in the above mentioned Starrett application (the latter disclosing the inter-channel noise suppression arrangement utilized herein), and comprises the utilization of the energy in the primary circuit
30 4, of the intermediate frequency amplifier output, for providing the automatic volume control voltage for the diode C—D₂.

The load circuit following the 55 tube may include the pentode tube 57, followed by output tubes 24, and a reproducer 25. In other words,
35 the tube 57 may function as a driver stage for the output stage 24.

Considering, now, the specific circuit connections between the amplifier 1, the tube 55 and the tube 57, it will be noted that the coupling network between the amplifier 1 and the tube 55
40 comprises the primary circuit coil 4 shunted by the condenser 4', the direct current energy being fed to the anodes of the amplifier 1 through the coil 4 from a source of anode potential supply B (not shown). The secondary circuit of the coupling network M includes the coil 5, magnetically coupled to the coil 4, and the shunt condenser 5'. The diode anode D₁ is connected to the high potential side of the coil 5, while the low potential
45 side of the said coil is connected through a path which includes the resistors 8, 9 to the cathode lead of tube 55. It will be understood, of course, that the primary and secondary circuits of the coupling network M are both maintained fixedly
50 tuned to the intermediate frequency employed in the receiver.

The diode anode D₂ is connected to the high potential side of the coil 4 through a path which includes the lead 30 and the fixed condenser 6,
55 the said diode anode additionally being connect-

ed to the grids of the intermediate frequency amplifier tubes through a path which includes the lead 12', the resistor 12 and the lead 26, a condenser 13 being connected between one side of the resistor 12 and ground, and a resistor 11
5 being connected between the other side of resistor 12 and ground. It is to be understood that the lead 26 is connected to the grids of the tubes of amplifier 1 in such a manner that the gain of the amplifier 1 is automatically controlled.
10 The manner of making this connection is too well understood by those skilled in the art to require any more than the conventional showing of the drawing.

The grid G of tube 55 is connected to a point
15 between resistors 8 and 9 through a path which includes the resistor 14 and the lead 14', the grid side of resistor 14 being connected to ground through the fixed condenser 15, and the resistors 8 and 9 being shunted by a condenser 7 which
20 functions to by-pass radio frequency currents. The anode P of tube 55 is connected to the control grid G₁ of pentode tube 57 through a path which includes the resistor 17, it being noted that the tube 57 is of the well known audio frequency
25 pentode type comprising the indirectly heated cathode, the heater therefor, the screen grid electrode disposed between the plate and the control grid G₁, and the suppressor grid S connected to the cathode, and disposed between the anode and
30 screen grid electrode. It is to be noted that the cathodes of both tubes 55 and 57 are energized by a heater element, and it is to be understood that this element is connected to the secondary
35 of the transformer winding supplying the heater circuit, as is well known to those skilled in the art.

The potentials for the anodes of tubes 55 and 57 are secured from the source B' (not shown). Thus, the anode of tube 57 is connected to the
40 positive terminal of source B' through a path which includes the coupling resistor 21, the resistors 19, 20, 21, 22 and 23 being arranged in series between the positive terminal of source B' and ground to provide the various electrode potentials for the tubes 55 and 57. The screen grid
45 electrode of tube 57 is connected, through lead 32, to the low potential side of resistor 23, the cathode of tube 57 being connected by lead 33 to the low potential side of resistor 22.

The potential for the anode P of tube 55 is provided through a path, from the positive terminal of source B', which includes the resistor 23, resistor 22, resistor 21 and the resistor 19.
50 The cathode C of tube 55 is connected by lead 34 to a point between resistors 19 and 20, the low potential side of resistor 19 being connected to the ground side of resistor 11.

The audio frequency signal path between the tube 55 and the amplifier tube 57 is provided by
55 lead 35 and condenser 19. The lead 35 is connected to the control grid side of resistor 17, and the condenser 19 has one of its terminals adjustably connected to a point on slider 9 by the slider 9'. It will be noted that the coupling between
60 the diode detector and the amplifier 57 is of the resistance-capacity type, while the coupling between the triode system of tube 55 and the amplifier 57 is of the direct coupled type. The amplifier 24 is resistively coupled, as at 31—31', to the
65 output circuit of amplifier 57.

Referring to the drawing for a clear understanding of the operation of the circuit, diode D₁ is connected to the secondary of the intermediate frequency transformer, through the resistor 9,
70 75

by-passed for radio frequency by condenser 7, and serves as a detector. The audio frequency developed here is passed to the grid of the amplifier tube 57 through condenser 10. The direct current voltage developed across 9 is placed between the grid G of the tube 55 and cathode, through resistor 14. Thus, with a signal on D₁ grid G is biased negatively enough to cut off the plate current through resistor 16. The grid bias on tube 57 is, then, that across resistor 21, which allows the tube to amplify normally.

When the receiver is detuned, the negative bias on grid G of tube 55 is reduced, and plate current through resistor 16 causes tube 57 to be cut off. The diode plate D₂ is coupled to the primary 4 of the intermediate frequency transformer through condenser 6. Rectified current through resistor 11 causes a voltage drop therethrough, when the peak radio frequency voltage is greater than the negative bias between D₂ and cathode C, obtained across bleeder resistor 19. The voltage drop through resistor 11 is used to control the bias of the preceding amplifier tubes, giving automatic volume control action.

The advantage of the connection of D₂ to primary coil 4 is due to the difference in selectivity as measured at the primary and secondary terminals. The secondary circuit is not effective in controlling the voltage on D₂ (except to a limited extent through its reaction on the primary circuit). The radio frequency input at coil 4 to the diode D₂ will be maintained at an approximately constant level by the automatic volume control action, but when the receiver is slightly detuned the input at coil 5 to the diode D₁ will drop below that at coil 4, causing the response in the audio system to be cut off.

This action also improves the discrimination against interchannel noise, since the noise voltage developed in the secondary will in general be less than that in the primary. This difference may be made enough so that the receiver will never respond to noise alone. The selectivity is apparently sharper than would be indicated by the real selectivity curve of the receiver, which at resonance will pass the side bands with the usual fidelity, but with mistuning of 3000 to 4000 cycles will eliminate response.

One of the important changes introduced by the present invention in the aforesaid Starrett application lies in taking the source of radio frequency supply to the automatic volume control diode D₂ from the primary of the last intermediate frequency (or radio frequency) transformer, instead of taking it from the secondary circuit. This means that the automatic volume control voltage passes through one less tuned circuit than does the detected voltage. The resonance curve, according to which the automatic volume control is regulated, is a broader one than the resonance curve applying to the detector. This results, so to speak, in having the detected, or audio response, fall off more quickly with detuning than does the rectified automatic volume control voltage. Consequently, the final audio response falls off more rapidly with detuning than it would if the automatic volume control voltage were supplied from a circuit affected by the last tuning stage as well as by the previous stages.

In the circuit shown, the carrier voltage for the automatic volume control is taken from the primary winding 4 and coupled to the diode D₂ by means of condenser 6. Rectified voltage is fed back to the intermediate frequency (or radio fre-

quency) amplifier through the resistance 12; this resistance together with condenser 15, serving to give the proper time constant for automatic volume control action. Signal voltage for detection is taken from the secondary winding 5 and supplied to the diode D₁ through the resistances 8 and 9, shunted by the condenser 7, the purpose of which is to by-pass radio frequency. Audio frequency voltage is taken from the resistance 9 by means of the coupling condenser 10, and applied to the grid of the first audio tube. However, when no signal is being received the plate current of the type 55 tube flowing through the resistance 16 is sufficient to bias the first audio tube to cut-off.

When a signal is received the drop in potential across the resistance 9 is sufficient to bring the grid G of the 55 to cut-off, thus removing the first audio tube from cut-off so that the signal supplied is effective. This arrangement provides for diode detection, diode automatic volume control and for noise suppression. Delayed automatic volume control of course may be readily arranged. It may in some cases be found desirable to couple the automatic volume control diode to a point more than one stage before the detector. Separate amplification before rectification may then be advantageous.

While I have indicated and described one 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, a source of intermediate frequency energy, a single stage including a pair of diodes and a triode system, a coupling network, comprising a primary and secondary circuit, between said source and one of said diodes, a connection between said primary circuit and the other diode, an audio frequency amplifier coupled to said triode system and said first diode, and inter-channel noise suppressor means including the control grid of said triode system for rendering said amplifier inoperative when the energy transmitted from said source decreases below a predetermined level.

2. In combination, a source of intermediate frequency energy, a single stage including a pair of diodes and a triode system, a coupling network, comprising a primary and secondary circuit, between said source and one of said diodes, a connection between said primary circuit and the other diode, an audio frequency amplifier coupled to said triode system and said first diode, and inter-channel noise suppressor means including the control grid of said triode system for rendering said amplifier inoperative when the energy transmitted from said source decreases below a predetermined level, said amplifier comprising a pentode tube, the control grid of the pentode tube being connected to the cathode and anode of said triode system through resistive paths.

3. In combination, a source of intermediate frequency energy, a single stage including a pair of diodes and a triode system, a coupling network, comprising a primary and secondary circuit, between said source and one of said diodes, a connection between said primary circuit and the other diode, an audio frequency amplifier coupled to said triode system and said first diode,

inter-channel noise suppressor means including the control grid of said triode system for rendering said amplifier inoperative when the energy transmitted from said source decreases below a predetermined level, said suppressor means comprising a resistor connected between the said first diode and said triode control grid, and a second resistor common to the anode of said triode system and the control grid of said amplifier.

4. In combination with a high frequency amplifier, a tube comprising a cathode, an anode, a control grid and a pair of auxiliary cold electrodes adjacent the cathode outside the electron flow to said anode, a primary coupling circuit connected to said amplifier, a secondary circuit coupled to said primary circuit, means for connecting one of the auxiliary electrodes and said cathode to said secondary circuit to provide a diode detection circuit, a connection between said primary circuit and the other auxiliary electrode, a gain control connection between the cathode and the said amplifier, a low frequency amplifier having its control grid circuit coupled to the said anode, means including a condenser coupling the low frequency amplifier input circuit to said diode detector circuit, a connection between the control grid of the first tube and a point on said diode detector circuit of such direct current potential value that the flow of current through said coupling between the anode of the first tube and the said low frequency amplifier control grid circuit is prevented when the signal energy in said primary circuit decreases below a desired level.

5. In combination with a high frequency amplifier, a tube comprising a cathode, an anode, a control grid and a pair of auxiliary cold electrodes adjacent the cathode outside the electron flow to said anode, a primary coupling circuit connected to said amplifier, a secondary circuit coupled to said primary circuit, means for connecting one of the auxiliary electrodes and said cathode to said secondary circuit to provide a diode detection circuit, a connection including a condenser between said primary circuit and the other auxiliary electrode, a gain control connection between the cathode and the said amplifier, a low frequency amplifier having its control grid circuit coupled to the said anode, means including a condenser coupling the low frequency amplifier input circuit to said diode detector circuit, a connection between the control grid of the first tube and a point on said diode detector circuit of such direct current potential value that the flow of current through said coupling between the anode of the first tube and the said low frequency amplifier control grid circuit is prevented when the signal energy in said primary circuit decreases below a desired level.

6. In combination with a high frequency amplifier, a tube comprising a cathode, an anode, a control grid and a pair of auxiliary cold electrodes adjacent the cathode outside the electron flow to said anode, a primary coupling circuit connected to said amplifier, a secondary circuit coupled to said primary circuit, means for connecting one of the auxiliary electrodes and said cathode to said secondary circuit to provide a diode detection circuit, a connection between said primary circuit and the other auxiliary electrode, a gain control connection including a bias resistor between the cathode and the said amplifier, a low frequency amplifier having its control grid circuit coupled to the said anode, means including a condenser coupling the low frequency am-

plifier input circuit to said diode detector circuit, a connection between the control grid of the first tube and a point on said diode detector circuit of such direct current potential value that the flow of current through said coupling between the anode of the first tube and the said low frequency amplifier control grid circuit is prevented when the signal energy in said primary circuit decreases below a desired level.

7. In combination with a high frequency amplifier, a tube comprising a cathode, an anode, a control grid and a pair of auxiliary cold electrodes adjacent the cathode outside the electron flow to said anode, a primary coupling circuit connected to said amplifier, a secondary circuit coupled to said primary circuit, means for connecting one of the auxiliary electrodes and said cathode to said secondary circuit to provide a diode detection circuit, a connection including a condenser between said primary circuit and the other auxiliary electrode, a gain control connection including a bias resistor between the cathode and the said amplifier, a low frequency amplifier having its control grid circuit directly coupled to the said anode, means including a condenser coupling the low frequency amplifier input circuit to said diode detector circuit, a connection including a resistor between the control grid of the first tube and a point on said diode detector circuit of such direct current potential value that the flow of current through said coupling between the anode of the first tube and the said low frequency amplifier control grid circuit is prevented when the signal energy in said primary circuit decreases below a desired level.

8. In a radio receiver including a high frequency amplifier and a low frequency amplifier, a diode rectifier circuit including an input network resonant to a desired signal frequency, a second network, resonant to said frequency, coupling the first network to said first amplifier, a second diode rectifier circuit, a path of low impedance to said signal frequency connected between said second network and said second diode circuit, an automatic gain control connection between said second diode circuit and said first amplifier, a path of low impedance to the low frequency component of the rectified signal frequency between the first diode circuit and said low frequency amplifier, an electron discharge device of the type provided with at least an electron emitter, an input electrode and output electrode and having its output electrode connected to the input circuit of the said low frequency amplifier, said device having its input electrode connected to a point of said first diode circuit of such direct current potential value that a predetermined decrease in said value results in a sufficient increase in direct current potential in said low frequency amplifier input circuit to bias the low frequency amplifier to cut-off.

9. In a radio receiver including a high frequency amplifier and a low frequency amplifier, a diode rectifier circuit including an input network resonant to a desired signal frequency, a second network, resonant to said frequency, coupling the first network to said first amplifier, a second diode rectifier circuit, a path of low impedance to said signal frequency connected between said second network and said second diode circuit, an automatic gain control connection between said second diode circuit and said first amplifier, a path of low impedance to the low frequency component of the rectified signal frequency between the first diode circuit and said

low frequency amplifier, an electron discharge device having an output electrode connected to the input circuit of the said low frequency amplifier, said device including an input electrode connected to a point of said first diode circuit of such direct current potential value that a predetermined decrease in said value results in a sufficient increase in direct current potential in said low frequency amplifier input circuit to bias the low frequency amplifier to cut-off, and a single envelope housing the electrodes of said first and second diodes and said electron discharge device.

10. In a radio receiver including a high frequency amplifier and a low frequency amplifier, a diode rectifier circuit including an input network resonant to a desired signal frequency, a second network, resonant to said frequency, coupling the first network to said first amplifier, a second diode rectifier circuit, a path of low impedance to said signal frequency connected between said second network and said second diode circuit, an automatic gain control connection between said second diode circuit and said first amplifier, a path of low impedance to the low frequency component of the rectified signal frequency between the first diode circuit and said low frequency amplifier, an electron discharge device of the type provided with at least an electron emitter, an input electrode and output electrode and having its output electrode connected to the input circuit of the said low frequency amplifier, said device having its input electrode connected to a point of said first diode circuit of such direct current potential value that a predetermined decrease in said value results in a sufficient increase in direct current potential in said low frequency amplifier input circuit to bias the low frequency amplifier to cut-off, said second path being adjustably connected to said first diode circuit.

11. In a radio receiver including a high frequency amplifier and a low frequency amplifier, a diode rectifier circuit including an input network resonant to a desired signal frequency, a second network, resonant to said frequency, coupling the first network to said first amplifier, a second diode rectifier circuit, a path of low impedance to said signal frequency connected between said second network and said second diode circuit, an automatic gain control connection between said second diode circuit and said first amplifier, a path of low impedance to the low frequency component of the rectified signal frequency between the first diode circuit and said low frequency amplifier, an electron discharge device of the type provided with at least an electron emitter, an input electrode and output electrode and having its output electrode connected to the input circuit of the said low frequency amplifier, said device having its input electrode connected to a point of said first diode circuit of such direct current potential value that a predetermined decrease in said value results in a sufficient increase in direct current potential in said low frequency amplifier input circuit to bias the low frequency amplifier to cut-off, and said connection between said device output electrode and said low frequency amplifier input circuit including a purely resistive coupling.

12. In a radio receiver including a high frequency amplifier and a low frequency amplifier, a diode rectifier circuit including an input network resonant to a desired signal frequency, a

second network, resonant to said frequency, coupling the first network to said first amplifier, a second diode rectifier circuit, a condensive path of low impedance to said signal frequency connected between said second network and said second diode circuit, an automatic gain control connection between said second diode circuit and said first amplifier, a path of low impedance to the low frequency component of the rectified signal frequency between the first diode circuit and said low frequency amplifier, an electron discharge device of the type provided with at least an electron emitter an input electrode and output electrode and having its output electrode connected to the input circuit of the said low frequency amplifier, said device having its input electrode connected to a point of said first diode circuit of such direct current potential value that a predetermined decrease in said value results in a sufficient increase in direct current potential in said low frequency amplifier input circuit to bias the low frequency amplifier to cut-off.

13. In a radio receiver including a high frequency amplifier and a low frequency amplifier, a diode rectifier circuit including an input network resonant to a desired signal frequency, a second network, resonant to said frequency, coupling the first network to said first amplifier, a second diode rectifier circuit, a path of low impedance to said signal frequency connected between said second network and said second diode circuit, an automatic gain control connection between said second diode circuit and said first amplifier, a condensive path of low impedance to the low frequency component of the rectified signal frequency between the first diode circuit and said low frequency amplifier, an electron discharge device of the type provided with at least an electron emitter, an input electrode and output electrode and having its output electrode connected to the input circuit of the said low frequency amplifier, said device having its input electrode connected to a point of said first diode circuit of such direct current potential value that a predetermined decrease in said value results in a sufficient increase in direct current potential in said low frequency amplifier input circuit to bias the low frequency amplifier to cut-off.

14. In combination, an amplifier of high frequency signal energy, a single stage including a pair of diodes and a triode, a coupling network, comprising a tuned primary and a tuned secondary circuit, between said amplifier and one of said diodes, a signal connection between said primary circuit and the other diode, an audio frequency amplifier coupled to said triode system and said first diode, an automatic volume control connection between the signal amplifier and the said other diode, and inter-channel noise suppressor means including a direct current connection between the circuit of said one diode and the control grid of said triode system for rendering said audio amplifier inoperative when the energy transmitted from said source decreases below a predetermined level, the resonance curve characteristic of the automatic volume control circuit being broader than that of the said one diode circuit whereby the audio amplifier response falls off more rapidly with detuning than does the automatic volume control response.

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