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DELAYED AUTOMATIC GAIN CONTROL CIRCUITS

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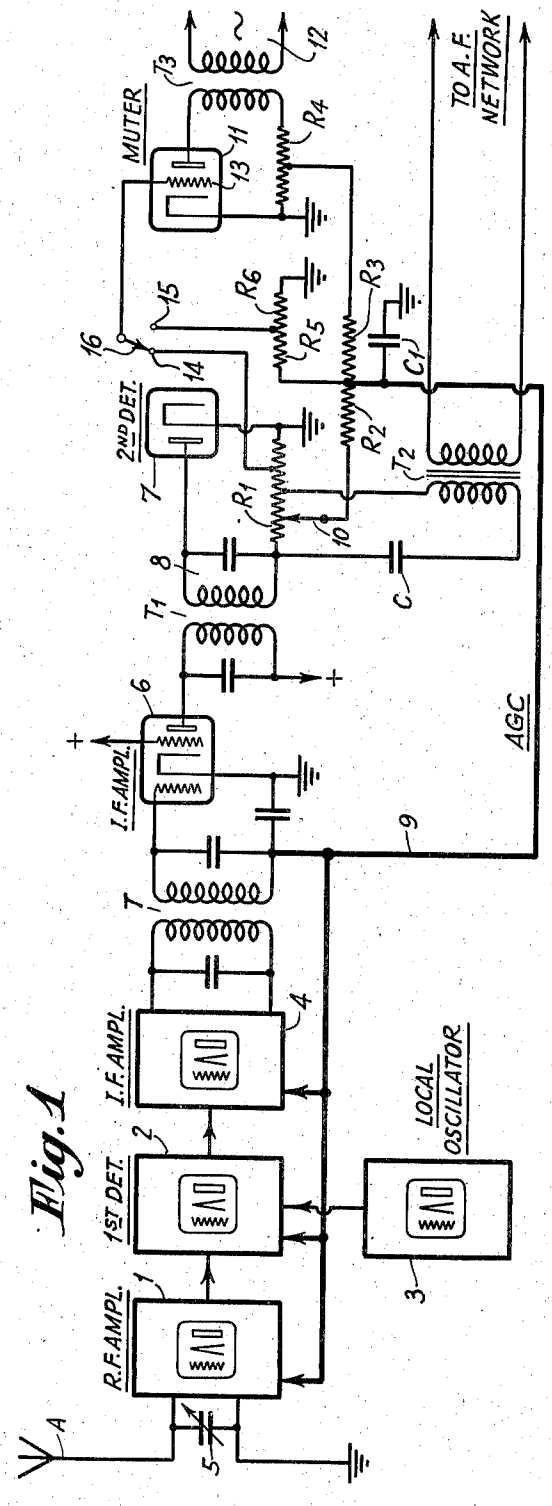


Fig. 1

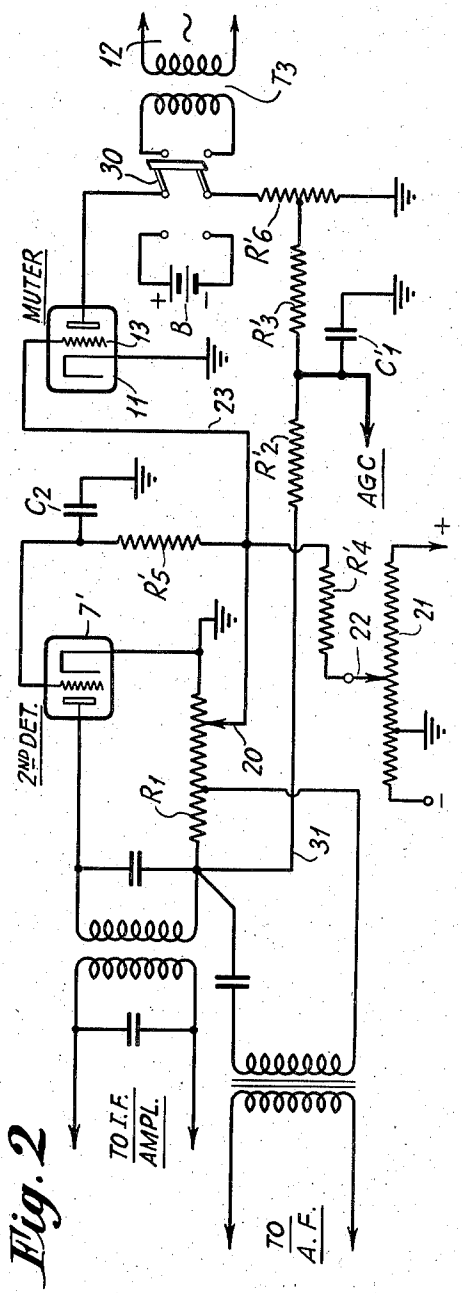


Fig. 2

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DELAYED AUTOMATIC GAIN CONTROL CIRCUITS

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4 Claims. (Cl. 250—20)

My present invention relates to gain control arrangements for radio receivers, and more particularly to automatic threshold gain control circuits for radio telephone and broadcast receivers.

Automatic muting, or noise squelching devices, for radio telephone and broadcast receivers best serve their purposes when they render the receiving circuits noiseless, as for example, when receiving intermittent signals such as police calls and the like, and yet, at the same time, are capable of holding the gain of the receiver within given limits during periods of selective fading. Additionally, such muting devices are most useful when they allow a fast rate of automatic gain control to operate within a given fading range. During periods of selective fading the carrier at times fades completely out of the receiver range, while concurrently the modulation side bands are received at about their normal amplitude. However, sometimes the modulation side bands are distorted, while at other times they are received with clarity, even though the carrier has faded in a marked fashion. It has been observed that the modulation side bands tend to fade simultaneously with the carrier, the higher the carrier frequency. For example when receiving a carrier of 18,000 kc., fading is accompanied by more of the side band components than is experienced when receiving 15,000 kc.; the effect being less pronounced on lower carrier frequencies.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a muting arrangement for a radio receiver of speech, or music, modulated carrier waves, wherein the muting arrangement acts on all tubes which are normally controlled by a bias derived from the received carrier energy, thereby giving improved reception of short waves, and with improvement on the broadcast band as well, this being accomplished by preventing the expansion of side band components as the carrier fades due to reduced automatic bias to the transmission tubes which are automatically controlled.

Another important object of this invention is to provide in a radio receiver of the superheterodyne type, a demodulator which functions to provide automatic gain control bias during reception of modulated carrier waves whose amplitude are above a predetermined threshold value, and the receiver additionally including a muter circuit which functions to apply an amplification reducing bias to the signal transmission tubes, normally under automatic gain control, whenever the received carrier amplitude falls below the threshold value.

Another object of the invention is to provide in a receiver of the type equipped with automatic gain control of the signal transmission tubes, a muting arrangement which becomes operative to hold the gain of the controlled tubes within certain limits when the received carrier falls below a predetermined amplitude level and the receiving arrangement additionally including as the demodulator thereof a diode circuit which varies in sensitivity inversely to the strength of the received carrier.

Other objects of the invention are to improve generally the efficiency of noise squelching circuits for speech, and music, modulated carrier receivers, and more especially to provide such squelching circuits in a reliable manner, and in a fashion such that they are readily manufactured and assembled in 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 diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 is a circuit diagram of a superheterodyne receiver embodying the present invention, and

Fig. 2 shows the circuit diagram of a modification of the arrangement of Fig. 1.

Referring now to the accompanying drawing, wherein like reference characters in the different figures designate similar circuit elements, the receiving system shown in Fig. 1 is of the superheterodyne type, and embodies the usual signal collector A which feeds a tunable radio frequency amplifier 1. The amplified signal output of amplifier 1 is fed to a first detector 2, and there is impressed on the first detector 2 the output of a local oscillator 3. The IF energy output of the first detector 2 is transmitted to one, or more, stages of IF amplification 4. The numeral 5 denotes in conventional manner the usual variable tuning elements of the networks 1, 2 and 3, and those skilled in the art are fully aware of the manner of constructing such uni-control condensers. It is noted that instead of utilizing separate tubes 2 and 3 for the first detector and local oscillator circuits, a composite first de-

tector-local oscillator network, using a tube of the pentagrid converter type, may be utilized.

In order to clearly demonstrate the manner of electrically connecting any of the signal transmission tubes, under automatic gain control, to the muting circuit, the last stage of IF amplification is shown in detail. This last stage includes a tube 6 whose input electrodes are coupled by the resonant IF transformer T to the output of the preceding IF amplifier 4. The plate circuit of tube 6 is coupled to the electrodes of the diode second detector 7 through an IF transformer T_1, and it is to be clearly understood that the primary and secondary circuit of each of the IF transformers is fixedly tuned to the operating IF. The frequency value of this IF will depend upon the operating frequency range of the receiver, and in receivers operating with modulated carriers of the order of 18,000 kc. the IF may have a value chosen from a range of 75 to 450 kc.

The diode 7 has its anode connected to the high alternating potential side of the resonant input circuit 8, while its cathode is grounded and also connected to the low alternating potential side of the input circuit 8 through a resistor R_1. The audio component of the demodulated IF energy is transmitted to the audio frequency utilization network through a circuit including the condenser C and the audio transformer T_2. The audio utilization network may comprise one, or more stages of audio frequency amplification followed by a reproducer of any desired type. The direct current component of the rectified IF energy is utilized for automatic gain control of the preceding signal transmission tubes. This is accomplished by connecting the grid circuits of the networks 1, 2 and 4 to a point on resistor R_1 which is at a negative direct current potential with respect to ground when signals are impressed on the input circuit 8 of the diode detector 7. The automatic gain control lead to the various controlled tubes is represented by the numeral 9, also designated by the letters AGC, and it will be noted that the lead 9 extends to the grid circuit of the IF amplifier 6. The cathode of the IF amplifier 6 is shown grounded, and it will therefore be appreciated that the direct current bias produced across the resistor R_1 is employed as the source of bias potential for the signal transmission tubes under gain control.

The lead 9 is connected to a desired point of resistor R_1 through a path including resistor R_2 and the adjustable tap 10; the junction of lead 9 and resistor R_2 is connected to ground through a condenser C_1. The muter circuit comprises an electron discharge tube 11 whose cathode is grounded, and between whose anode and ground is connected a resistor R_4. The tube 11 employs the cathode and anode thereof to function as a rectifier of alternating current energy, derived from a source 12 which is not shown, and which energy is impressed between the anode and cathode of tube 11 through a transformer T_3. A control grid 13 is disposed between the cathode and anode of tube 11, and the variation in bias of the grid 13 varies the magnitude of the rectified alternating energy appearing across the load resistor R_4. The grid 13 may be connected to a contact 14, or a second contact 15, by means of an adjustable switch element 16. The contact 14 connects to a point on diode demodulator load resistor R_1, which point is at a positive direct current potential with respect to the point to which tap 10 is connected when signals are impressed on input circuit 8.

The contact 15 is connected to the junction of resistors R_5 and R_6, one side of the resistor R_6 being grounded, and one side of resistor R_5 being connected to the junction of resistors R_2 and R_3. As stated before, the tube 11 functions as a rectifier of local alternating current energy. The latter may be chosen to have a frequency value from a range of 60 cycles to 300 kc. For broadcast reception, 60 cycles may be used. The rectified alternating current voltage developed across resistor R_4 functions as a source of bias supply for the stages 1, 2, 4 and 6 when the modulated carrier is not impressed on the input circuit 8 of the demodulator. As long as signals are being received which have a carrier amplitude above a predetermined threshold value, the tube 11 is biased to cut-off, or nearly so, by the negative voltage developed across load resistor R_1. This biasing voltage for the grid 13 of tube 11 may be transmitted directly through contact 14, or it may be impressed upon the grid 13 through the time delay circuit R_2—R_3—C_1, in proportion to the divided values of resistors R_5—R_6. In other words the adjustment of switch 16 to contact 15 results in a delay of the action of muter tube 11.

The direct current component of rectified signal current developed across the resistor R_1 supplies the negative voltage for AGC, and renders tube 11 non-conductive. When the carrier fades to the point where its amplitude falls below a predetermined threshold value, whether below or above the linear range of the AGC characteristic of the receiver, the tube 11 suddenly becomes conductive, and supplies sufficient AGC voltage to the controlled transmission tubes to keep the gain of the receiver from increasing to over-amplify the modulation side bands. In other words when the carrier amplitude falls below a predetermined threshold value, the normal AGC rectifier is supplemented in its biasing action by an auxiliary alternating current rectifier. The latter acts to furnish additional negative bias, and thus keeps the signal transmission amplifiers from the normal tendency to increase in gain as the normal AGC action decreases. This control in amplification of the controlled tubes, when the carrier falls below the desired threshold value, may be adjusted so that distortion effects due to selective fading, of the type described above, will be effectively suppressed. Those skilled in the art are fully aware of the bad effects of flutter fading, a phenomenon which manifests itself by virtue of the selective fading between the carrier and its modulation side bands. A circuit of the present type acts to reduce such flutter fading.

The arrangement in Fig. 2 illustrates a modification whose operation is similar to that shown in Fig. 1, except that the sensitivity of the diode detector 7 varies inversely to the carrier strength. Only those portions of the circuit arrangement will be described which are essential to a complete understanding of this modification. The numeral 7' denotes a grid controlled diode demodulator which is rendered sensitive by the positive voltage applied through the path including resistor R'_4 and time delay network R'_5 and condenser C_2; the same positive voltage being applied through the path including adjustable tap 20 and resistor R_1, to the anode of detector tube 7'. The positive voltages are derived from the usual voltage bleeder supply source 21, and the resistor R'_4 may be connected to a desired positive point on the bleeder 21 through an ad-

justable tap 22. These positive voltages applied to the grid and plate of tube 7' do not render the tube highly conductive. The muter tube 11 is, also, made sensitive by the same positive voltage applied to the grid 13 thereof through a path which includes the lead 23, and the resistor R'4.

The bias voltage across the load resistor R'6, which resistor is disposed in the space current path of muter tube 11, may be produced by plate current drawn by the battery voltage source B, or by the source of alternating current 12 which is coupled to the plate circuit through the transformer T_3. The numeral 30 denotes a switch device which may be used to connect either the source 12 to the plate circuit of tube 11, or the battery source B.

For the "No signal condition" the AGC bias is derived from the auxiliary rectifier load resistor R'6, and this bias is fed to the AGC circuit through the network including resistor R'3 and condenser C'_1. AGC bias is applied to the plate circuit of the detector 7' in opposition to the small positive voltage, impressed through resistor R'4, and reduces the positive bias on the grid of tube 7' to a certain extent. It will be noted that the anode of tube 7' is connected to the resistor R'6 through a path which includes the lead 31, the resistor R'2 and resistor R'3.

When carrier signals are received, the demodulator tube 7' draws space current, which corresponds to the rectified carrier, and the muter tube 11 is rendered partially, or wholly, non-conductive. In this case the AGC bias is derived wholly, or in part, from the voltage drop across resistor R_1, instead of from across resistor R'6. The grid of demodulator 7' also becomes less positive, and the diode demodulator space current is controlled in a manner similar to the transmission tubes whose gain is automatically regulated. The time delay circuit C_2—R'_5 prevents the AGC from distorting demodulation in the detector circuit, just as the network C'_1—R'_3—R'_2 prevents distortion within the signal transmission tubes whose gain is under control.

It will now be seen that there has been disclosed a practical and effective arrangement for overcoming the effects of selective fading in broadcast and radio telephone receiving systems, and wherein the direct current from an auxiliary alternating current rectifier is used to develop voltage for replacing the rectified carrier energy, normally used for AGC action, in a complementary manner when the received carrier fades. The complementary control bias network holds the gain of the receiver at about its gain value as before a sudden fading; reducing the undesirable sound effects arising with sudden carrier fading.

While I have indicated and described several systems 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 organizations 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 is claimed is:

1. In a radio receiver of the type utilizing a signal transmission tube and a signal rectifier fed with signal energy from the transmission tube, an automatic gain control circuit electrically connected with the rectifier and transmission tube and operating automatically to decrease the gain of the transmission tube as the signal carrier amplitude at the rectifier increases above a predetermined threshold value, an auxiliary rectifier, a source of alternating current energy coupled to the auxiliary rectifier, said auxiliary rectifier including a load impedance for developing a direct current voltage from the rectified alternating current energy, means for impressing the direct current voltage upon said transmission tube in a sense to prevent increase of the gain of said signal transmission tube thereby to prevent more efficient transmission of modulation side bands with respect to the carrier when the latter decreases in amplitude below said threshold value, and additional means, responsive to an amplitude increase in signal carrier impressed on the first rectifier above said predetermined threshold value, for rendering said auxiliary rectifier inoperative to control the gain of said transmission tube.

2. In a radio receiver of the type utilizing a modulated signal carrier transmission tube and a signal rectifier fed with signal energy from the transmission tube, an automatic gain control circuit electrically connected with the rectifier and transmission tube and operating automatically to decrease the gain of the transmission tube as the signal carrier amplitude at the rectifier increases above a desired level, an auxiliary rectifier, a source of alternating current energy coupled to the auxiliary rectifier, said auxiliary rectifier including a load impedance for developing a direct current voltage from the rectified alternating current energy, means for impressing the direct current voltage upon said transmission tube in a sense to prevent increase of the gain of said signal transmission tube when the carrier amplitude decreases below said level and the modulation frequencies are thereby more efficiently transmitted than the carrier frequency, additional means, responsive to an increase in signal carrier amplitude at the first rectifier above said level, for rendering said auxiliary rectifier ineffective to control the gain of said transmission tube, and means controlling said signal rectifier for varying it in sensitivity to the strength of the received carrier.

3. The method of operating a receiving system in a manner to reduce the effect of relative fading between a carrier and its modulation side bands, which method includes the steps of transmitting the carrier and modulation side bands through a signal transmission tube, rectifying the transmitted energy, deriving a direct current voltage from the rectified carrier energy, impressing said direct current voltage upon the transmission tube in a sense to decrease the action of the transmission tube as the carrier amplitude increases, rectifying alternating current energy to produce a second direct current voltage, impressing the second voltage upon said transmission tube in a sense to prevent increase of the gain of the transmission tube when the carrier amplitude decreases below a predetermined amplitude value and fails to furnish said first named voltage, and utilizing the first direct current voltage to render the production of the second direct curent voltage ineffective when the received carrier amplitude increases above said amplitude value.

4. A method of operating a modulated signal carrier receiver of the type including at least a signal amplifier feeding a detector, said method including the steps of impressing signal carrier energy on the amplifier for amplification, automatically reducing the gain of the amplifier with a uni-directional voltage derived from received

carrier energy as the carrier amplitude increases above a desired level thereby to maintain the carrier amplitude at the detector input substantially uniform, automatically controlling the gain of said amplifier in a sense to prevent its increase above a value established at said carrier amplitude level when said carrier energy amplitude falls below said level and the modulation frequencies are amplified by the amplifier to a greater extent than the carrier frequency, and causing said unidirectional voltage to render said automatic control of the amplifier gain ineffective upon an increase of the carrier amplitude above said level.

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