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AUTOMATIC VOLUME CONTROL CIRCUIT

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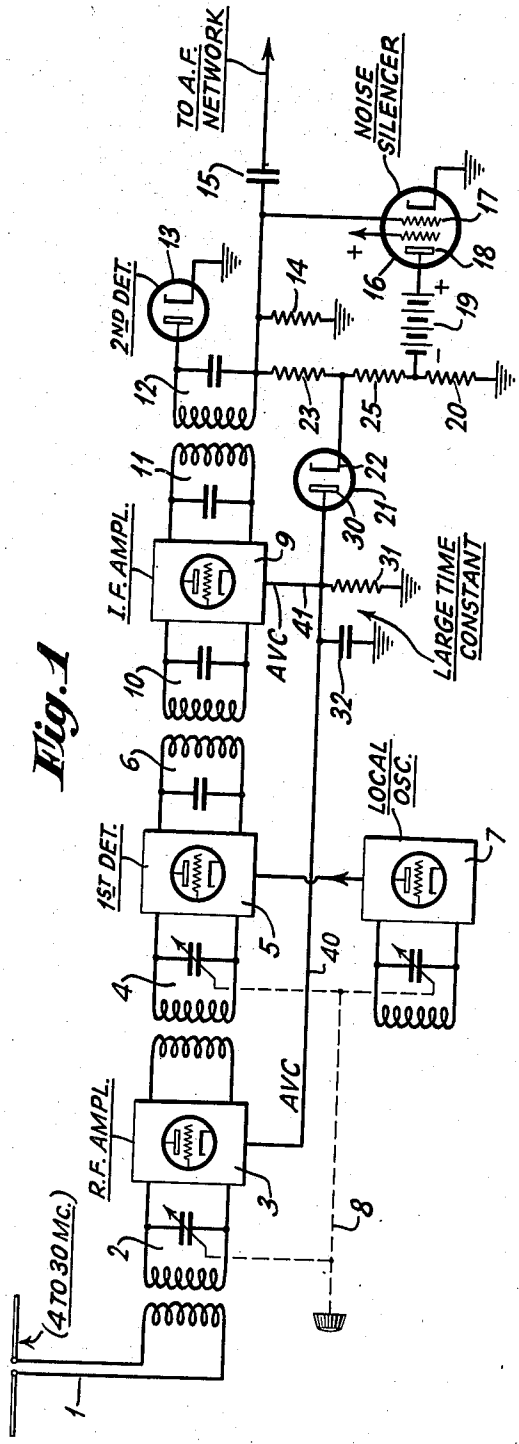


Fig. 1

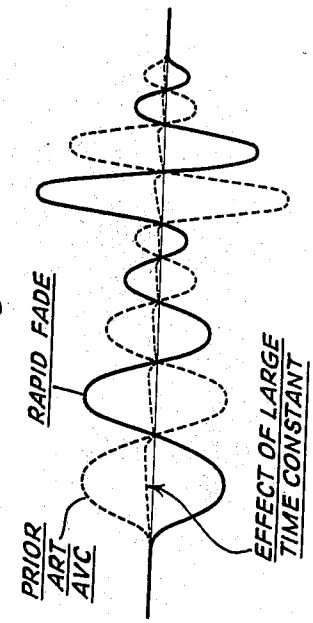


Fig. 3

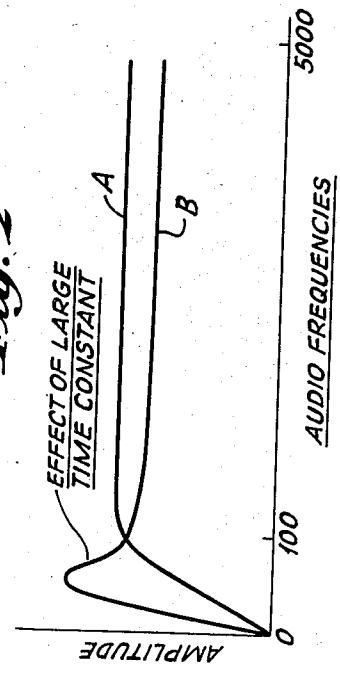


Fig. 2

INVENTOR
R. LEE HOLLINGSWORTH

BY H. S. Grover

ATTORNEY

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AUTOMATIC VOLUME CONTROL CIRCUIT

R. Lee Hollingsworth, Riverhead, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

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5 Claims. (Cl. 250—20)

My present invention relates generally to automatic gain control circuits, and more particularly to automatic volume control circuits of the type adapted for use in receiving signals in the ultra-short wave band.

Automatic gain control arrangements which are in use at the present time in receiving signals in the 4–30 megacycle (mc.) band have several operating limitations. In the first place, the rate of compensation is the same for ascending and descending signal carrier levels with the result that on the ascending portions of the fading periods blasting effects are had. In other words, during the rapid fading which is experienced in the ultra-short wave band, the conventional type of automatic gain control circuit produces a rate of compensation which is not significantly better than the rapid fading itself. A second undesirable effect which is encountered when utilizing present automatic gain control (AGC) circuits in the ultra-short wave band is a reduction of the amplitude of the lower audio frequency components. That is to say, there is discernible a decided droop in the audio frequency response characteristic for frequencies below approximately 100 cycles.

It may, therefore, be stated that it is one of the main objects of my present invention to provide an AGC circuit for a short wave receiver wherein the action of the control circuit approaches that which is had in short wave communication when employing two-set diversity reception for telephone communication, and the essential and outstanding characteristics of the novel control circuit comprising instantaneous fading compensation without reducing the low audio frequency response, and the AGC time constant network being so chosen as to cause smooth receiver gain control action thereby substantially eliminating blasting effects on the ascending portion of the rapid fade.

Another important object of this invention is to provide an automatic volume control circuit for a short wave receiver wherein the volume control circuit is provided with a device of unidirectional conductivity, and a time constant network whose magnitude is sufficiently large to provide substantially smooth fading compensation for rapid fading without effect on the lower audio frequencies of the modulation range.

Still other objects of my present invention are to improve generally the efficiency and reliability of automatic gain control circuits for short wave receivers, and more especially to provide an automatic gain control circuit for short wave receivers which is simply and economically assembled in the receiver.

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 a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a short wave superheterodyne receiver embodying the present invention,

Fig. 2 graphically shows the effect of the invention on the lower portion of the audio range,

Fig. 3 graphically illustrates the manner in which the present invention provides smooth fading compensation.

Referring now to the receiving system shown in Fig. 1, it is to be understood that the latter may be a superheterodyne receiver of the type shown employed in short wave telephony. The receiving band in such a receiver may be of the order of 4–30 mc., and the receiver will be provided with a dipole 1 for collecting the short wave signals. The antenna may be of the usual grounded antenna type if desired, or it may even be a radio frequency line capable of distributing signals in the specified signal range. The signal collector device is coupled to the tunable input circuit 2 of the radio frequency amplifier 3, and the amplifier may comprise one or more stages of tunable modulated carrier amplification. The amplified modulated carrier signals are impressed upon the tunable input circuit 4 of a following first detector 5, and the output circuit of the latter is designated by numeral 6.

It will be understood that circuit 6 is resonated to the operating intermediate frequency (I. F.). The latter may be chosen from a range of 75–450 kc. The numeral 7 denotes the usual tunable local oscillator which produces oscillations of a frequency constantly differing from the frequency of the signals impressed upon the first detector 5 by the value of the I. F. The numeral 8 designates the customary and conventional tuning control mechanism which mechanically couples the adjustable elements of the various tuning devices of the tunable circuits of networks 3, 5 and 7. The I. F. amplifier 9 may comprise one or more stages of I. F. amplification, and the input circuit 10, coupled to the detector output circuit 6, is fixedly tuned to the I. F. value.

The I. F. output circuit 11 is coupled to the input circuit 12 of the second detector 13. The latter is shown as being of the diode type, and has its anode connected to the high alternating potential side of the input circuit 12. The low potential side of input circuit 12 is connected to ground by a load resistor 14, while the cathode of diode 13 is also grounded. There is developed across resistor 14 rectified voltage which is derived from the modulated carrier signals at I. F. The audio frequency component of the rectified I. F. currents is fed to a succeeding audio frequency network through condenser 15. The audio network may comprise one or more stages of audio amplification, and the last stage may be followed by any desired type of reproducer. The direct current voltage component of the rectified I. F. currents is utilized in two paths now to be described.

One of these paths comprises a so-called "noise silencer" device. The device comprises an electron discharge tube 16 whose input grid 17 is connected to the anode end of resistor 14. The plate 18 of tube 16 is connected to ground through a path which includes the direct current source 19 and the resistor 20, it being noted that the plate 18 is connected to the positive terminal of source 19. The cathode of tube 16 is at ground potential. Hence, when normal electron flow takes place from the cathode to the plate 18 of tube 16 direct current voltage is developed across resistor 20.

The magnitude of the direct current voltage developed across resistor 20 depends upon the bias of grid 17 with respect to the cathode of tube 16. The bias of grid 17 in turn is dependent upon the direct current voltage developed across resistor 14 due to rectification of the I. F. signal currents. The second path which utilizes the direct current voltage developed across resistor 14 comprises a device of uni-directional conductivity, such as diode 21. The cathode 22 of the diode 21 is connected through resistor 23 to the anode end of resistor 14. The cathode 22 is also connected through resistor 25 to the ungrounded end of resistor 20. The anode 30 of diode 21 is connected to ground through the resistor element 31, the latter being shunted by condenser 32. The anode 30 has direct current voltage connections 40 and 41 to the stages of the receiver whose gain is to be controlled in dependence on the magnitude of the signal carrier. In other words, the connections 40 and 41 are the automatic volume control (AVC), or automatic gain control, which is utilized to vary the gain of each of the controlled stages in such a sense that the carrier amplitude at the detector input circuit 12 is substantially uniform over a wide range of carrier amplitude variation at the signal collector 1.

In the absence of received signals there is substantially no direct current voltage developed across resistor 14. Consequently, the grid 17 of tube 16 has minimum negative bias. This results in maximum space current flow through tube 16 with a resulting large direct current voltage developed across resistor 20. Since cathode 22 of diode 21 is connected to the end of the resistor 20 which becomes increasingly negative with respect to ground as the voltage drop across resistor 20 increases, it follows that anode 30 of diode 21 will assume a positive potential with respect to cathode 22. In that case diode 21 is conductive, and, therefore, the controlled stages 3 and 9 will have negative bias applied thereto. In other words, assuming that the signal grids of each of the radio frequency and intermediate frequency amplifiers are connected to connections 40 and 41, then these signal grids will be established at a high negative bias when the drop across resistor 20 is a maximum. As a result the gain of controlled stages 3 and 9 will be greatly reduced, and the electrical noise impulses, which normally would be detected at 13, will not be heard due to the greatly reduced gain of amplifiers 3 and 9.

However, as the received signals increase in amplitude, direct current voltage is developed across resistor 14. This causes the negative bias on grid 17 to increase thereby reducing the voltage developed across resistor 20. A point is soon reached where the diode 21 is non-conductive. This means that the gain of each of stages 3 and 9 is restored to optimum. As the received signals increase in amplitude above a predetermined weak carrier amplitude the direct current voltage developed across resistor 14 increases in magnitude, and eventually completely cuts off tube 16 so that no voltage is developed across resistor 20. However, since the cathode 22 is connected through path 23 to the anode end of resistor 14, the cathode 22 becomes negative with respect to the diode anode 30 with the result that the diode 21 again becomes conductive, and permits the increasing negative bias derived from resistor 14 to be applied over connections 40 and 41 as an AVC bias. Resistors 23 and 25 function as filter resistors, and may each have magnitudes of approximately 200,000 ohms.

The network 31—32 has a large time constant, and resistor 31 may have a value of approximately 1 megohm whereas condenser 32 may be chosen from a range 0.1 to 1.0 microfarad. The large time constant network 32—31 permits very fast AVC action to occur without reducing the low audio frequencies. As a matter of fact there is had an accentuation of the lower audio frequencies. In Fig. 2 there is shown (curve A) the reduction of the lower audio frequencies, up to about 100 cycles, when the time constant network 32—31 has a small time constant value. The curve B denotes the accentuation of the lower audio frequencies up to about 100 cycles, caused by the utilization of the large time constant network in conjunction with the diode device 21. This compensation of low audio frequency curtailment, and indeed accentuation of the lower audio frequencies, is of advantage in receiving short wave telephony signals since the quality of these received signals is maintained substantially higher than has been thought hitherto possible.

There is also secured smooth control action because of the provision of a reasonable amount of "hold over" in the time constant network 32—31. In Fig. 3 the full line curve shows an illustrative rapid fading period. The dash line surve, designated "Prior art AVC," illustrates the type of fading compensation which has been secured in the prior art when using a fast acting AVC circuit. The dash line curve designated "Effect of large time constant" illustrates the smooth AVC action which is secured with the present invention, and such smooth rapid fading compensation is provided by the combined actions of the diode 21 and the large time constant network 32—31. Automatic gain control systems in use at the present time have a rate of compensation which is the same for ascending or descending signal carrier levels.

On the ascending part of a fade, the present invention permits the number of negative electrons to increase very rapidly in the time constant network 32—31 through a one-way circuit thereby positively controlling the upper halves of the carrier magnitude increase. If a conventional gain control system were allowed to operate as fast as in the present case, reduction of the audio frequency compensation would result. In the present case, as has been previously pointed out, the magnitudes of the time constant elements are increased so that there is produced a considerable amount of audio compression in the receiver audio output. The instantaneous action of the AVC circuit through unidirectional device 21 permits the condenser 32 to act in the manner of a low audio response equalizer across the diode output, but only through that period of time when the flow of electrons will be increased through the series feed tube, i. e., on sudden carrier level increases or on modulation level increases. A degree of compression with improved carrier control greatly improves the overall equality of the set when listening in on short wave, long distance circuits.

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 an automatic volume control circuit for a radio receiver, a rectifier having a signal input circuit and a load element across which is developed rectified signal voltage, and automatic volume control path connected to said load element which includes a series device of uni-directional conductivity, said device being rendered conductive upon development across said load element of rectified voltage whose magnitude exceeds a predetermined amplitude, and a relatively large time constant network operatively associated with said series device for rendering the automatic volume control fast and relatively smooth, a second device having a second load element in circuit therewith for developing a direct current voltage, means for applying said direct current voltage to said first device thereby rendering the latter conductive for signals less than a predetermined minimum amplitude, and means responsive to the voltage developed across said first load element for rendering the second device ineffective.

2. In a radio receiver provided with a detector adapted to develop direct current voltage whose magnitude is proportional to the received signal carrier amplitude, an automatic gain control connection to said detector, said connection including a diode in series therein, said diode being rendered conductive upon the development of said voltage to a value above a predetermined magnitude, means responsive to said voltage when less than said predetermined magnitude for rendering said diode conductive independently of said developed voltage, a time constant network of relatively large magnitude operatively associated with said diode.

3. In a radio receiver of the type including a modulated carrier signal amplifier arranged in cascade with a detector, means operatively associated with said detector for deriving a uni-directional voltage from detected modulated carrier signals, an automatic gain control connection between said detector and said amplifier, said connection including a device of uni-directional conductivity which is so constructed, and so arranged in said connection, that the device becomes conductive in response to said uni-directional voltage exceeding a predetermined amplitude, means responsive to said voltage decreasing below said amplitude for rendering said device conductive thereby to bias said amplifier, and said connection including a large time constant network for rendering the volume control action relatively fast but relatively smooth.

4. In a radio receiver of the type including a modulated carrier signal amplifier arranged in cascade with a detector, means operatively associated with said detector for deriving a uni-directional voltage from detected modulated carrier signals, an automatic gain control connection between said detector and said amplifier, said connection including a device of uni-directional conductivity as the sole coupling element between the detector and amplifier, said device being so constructed, and so arranged in said connection, that the device becomes conductive in response to said uni-directional voltage exceeding a predetermined amplitude, means responsive to said uni-directional voltage in excess of said predetermined amplitude for rendering said device conductive, said last means being rendered ineffective in response to an increase in uni-directional voltage substantially above said predetermined amplitude, and said connection including a large time constant network for rendering the volume control action relatively fast but relatively smooth, and the constants of said time constant network being so chosen that the low modulation frequency amplitudes are substantially accentuated.

5. In a radio receiver of the type including a modulated carrier signal amplifier arranged in cascade with a detector, means operatively associated with said detector for deriving a uni-directional voltage from detected modulated carrier signals, an automatic gain control connection between said detector and said amplifier, said connection including a device of uni-directional conductivity which is so constructed, and so arranged in said connection, that the device becomes conductive in response to said uni-directional voltage exceeding a predetermined amplitude, and said connection including a large time constant network for rendering the volume control action relatively fast but relatively smooth, a device adapted to produce a second uni-directional voltage, means for applying said second voltage to said device of uni-directional conductivity thereby rendering the latter conductive when the second voltage has an amplitude above a predetermined value, and means responsive to said first uni-directional voltage for rendering the said second uni-directional voltage device ineffective.

R. LEE HOLLINGSWORTH.