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AUTOMATIC GAIN EXPANSION CIRCUIT

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My present invention relates to volume expansion circuits, and more particularly to a simplified type of automatic gain expansion network for a radio telephone receiver.

In the past it has been customary to utilize relatively complicated and expensive circuits and equipment to obtain volume expansion for the conventional broadcast receiver. As is well known, in a volume expansion circuit for a broadcast receiver it is desired to increase the gain of the signal amplifiers relatively more for modulation frequencies of high amplitude than for low amplitude. In other words, it is desired to have increased volume of reproduction during louder passages of the audio modulation than during the weaker passages. Briefly, the reason for this volume expansion resides in the fact that the transmitter either designedly or inherently compresses, or contracts, the audio amplitude range of the modulation frequencies.

It may, therefore, be stated that it is one of the main objects of my present invention to provide a highly simplified form of volume expansion network for a radio receiver, wherein the expansion network involves only the addition of simple elements to the existing automatic volume control arrangement of the receiver.

Another important object of the invention may be stated to reside in the provision of a radio receiver equipped with an automatic volume control circuit for regulating high frequency amplifier gain, and wherein the addition of a diode and resistor in shunt with an element of the volume control circuit provides reliable volume expansion during loud audio passages.

Still another object of the invention may be stated to reside in the provision of an automatic expansion network for a broadcast receiver of the type provided with an automatic volume control circuit, the expansion network consisting of a diode and resistor arranged in shunt with the resistor of the time constant network of the volume control circuit.

Still other objects of my invention are to improve generally the simplicity and efficiency of volume expansion circuits, and more especially to provide a volume expansion network for a radio broadcast receiver which is not only reliable and efficient in operation but is economically manufactured and assembled in radio 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 diagrammatically a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a circuit diagram of a superheterodyne receiver embodying the invention,

Fig. 2 graphically illustrates the functioning of the expansion network.

Referring now to the accompanying drawing, there is shown in schematic manner the fundamental networks of a modern broadcast receiver of the superheterodyne type. Such a receiver is universally employed for broadcast reception over the 550 to 1,500 kilocycle range. As is well known to those skilled in the art, such a receiver comprises a first detector network 1 which usually includes a tunable circuit input 2, and the input circuit may be coupled to one or more tunable radio frequency amplifiers. The latter amplifiers are not shown, but it is well known that they will be simultaneously tuned with the variable tuning condenser 3 of the first detector. Of course, the usual signal collecting device will be connected to the first of the tunable amplifiers. The local oscillator 4 is provided with a tunable tank circuit 5, and the usual mechanical uni-control device will be employed, shown by dotted lines 6, to vary the variable condensers 3 and 5 over the operating frequency range. Of course, the mechanical uni-control device 6 may concurrently operate the variable condensers of the tunable radio frequency amplifiers. The local oscillations are impressed upon the first detector network in any desired manner, and in the output circuit 7, which is fixedly tuned to the operating intermediate frequency, there is produced the intermediate frequency voltage.

The intermediate frequency value may be chosen from a range of 75 to 400 kilocycles if desired, and the intermediate frequency voltage may be impressed upon an intermediate frequency amplifier network 8. This network 8 is shown provided with input and output circuits 9 and 10 respectively tuned to the operating intermediate frequency. The second detector comprises a diode 11 whose anode is connected to its cathode through a path which includes the tuned input circuit 12 and the load resistor 13. The tuned input circuit 12 is resonated to the operating intermediate frequency, and the intermediate frequency bypass condenser 14 is shunted across load resistor 13.

The audio voltage component of the rectified

signal voltage developed across resistor 13 is taken off from the latter by a slidable tap 15, and is then impressed upon the succeeding audio frequency amplifier through the audio coupling condenser 16. The audio frequency network may include one or more amplifiers followed by a reproducer. In order to maintain the carrier amplitude at the detector anode 12 substantially uniform regardless of a wide range of carrier amplitude variation at the signal collector device, there is utilized an automatic volume control circuit (designated A. V. C. in the drawing).

This A. V. C. circuit comprises a direct current voltage connection 20 between the anode end of load resistor 13 and the signal control grids of one or more of the preceding signal transmission tubes. If desired, the control connection may be made to each of the signal grids of each of the radio frequency amplifiers, the first detector tube and each of the intermediate frequency amplifier tubes. As is well known to those skilled in the art, in the absence of received modulated carrier energy a minimum of voltage is developed across resistor 13. Hence, the various signal transmission tubes operate at maximum gain. However, if the carrier amplitude increases at the signal collector then the direct current voltage developed across resistor 13 increases in magnitude with the result that the control bias applied to the signal grids increases and the gain of each of the control tubes is decreased. Hence, in spite of a wide range of carrier amplitude variation at the signal collector the A. V. C. circuit tends to maintain the carrier amplitude at input circuit 12 substantially uniform. In order to make sure that the A. V. C. circuit functions only for slow fading effects of the carrier there is usually provided in series in lead 20 a resistor 21, the condenser 22 shunting one end of the resistor to ground. Elements 21—22 provide the well known time constant circuit of the A. V. C. arrangement. These elements further function to prevent demodulation voltage from being impressed on the signal grids of the controlled tubes.

In shunt with the time constant resistor 21 there is provided a simple diode 23 and a resistor 24 whose magnitude is designated as adjustable by the arrow passing therethrough. The cathode of diode 23 is connected to the condenser end of resistor 21, while the anode of diode 23 is connected to the anode end of resistor 21 through the adjustable resistor 24. The series elements 23 and 24 comprise the volume expansion network of the system. With the addition of these two simple elements it is possible to secure a relatively greater increase in volume during loud audio passages than during weak passages.

In normal operation the condenser 22 charges to such a value that the potential thereacross and across the load resistor 13 are equal and well below the overload point of the resistor. This is the normal fashion in which the A. V. C. circuit operates. Referring to Fig. 2, let it be assumed that the line R represents the steady diode current through resistor 13, and that the curve S represents the violent fluctuations of this current when modulation is superimposed upon the incoming carrier. The curves in Fig. 2 are secured by plotting "time" as abscissae against "voltage" as ordinates. The curve R may also be considered to represent the voltage developed across condenser 22. In the normal type of A. V. C. circuit, that is one which does

not include diode 23 and resistor 24, the fluctuations due to modulation are present across condenser 22, but they are greatly attenuated due to the slow time constant of the time constant network 21—22.

However, the addition of the diode 23 provides a low resistance path for the positive swings of this modulation. The effect of this is to decrease the charge of the condenser 22 from the steady value R to a value such as is designated by the dotted line T during modulation. This decrease in bias consequently results in an increase in gain of the controlled tubes whose signal grids are connected to the connection 20. Hence, there results an increase in loudspeaker volume over that which would be observed without this change in bias to the value T. The adjustable resistor 24 permits a manual control of this effect. For example, if the resistor 24 be given a large value, then the change in bias due to modulation will be small and the resulting volume expansion slight. If, however, the resistor 24 be given a small value, then the resulting change in bias will be large with a corresponding increase in volume expansion.

For a certain setting of the value of resistor 24 it is obvious that the change in bias varies with depth of modulation. In other words, the more deeply the transmitter is modulated the greater will be the volume increase over normal, which is a requirement of an expander circuit. The resistor 21 allows condenser 22 to retain its normal potential during periods of little or no modulation. Again, resistor 21 permits condenser 22 to build up a greater charge should fading cause the incoming carrier to increase in strength. For decreases in carrier strength the diode 23 and resistor 24 both operate to decrease the charge on condenser 22. In other words, the normal functioning of the A. V. C. circuit is little affected by this change.

The essential function of path 23—24 may be summed up as follows: The object is to rectify the modulation voltage, and apply it to condenser 22 with such a polarity that it tends to decrease the voltage on 22 as normally fed to it from load resistor 13 through time constant resistor 21. Thus, if one considers for a moment a steady carrier with no modulation, the circuit without the expansion network will soon reach a steady state in which a certain charge will collect on condenser 22. The gain of the system being controlled by this charge will, of course, remain constant. Now, if a passage of modulation signal appears on the carrier a small amount of this alternating current will reach condenser 22 through resistor 21, but this alternating current will be so attenuated in value as to cause no appreciable fluctuation in circuit gain. The addition of the expansion network, however, modifies this. The steady-state, no-modulation condition is unchanged, but when a passage of modulation appears on the carrier a part of this alternating current voltage which will appear across 13 is rectified by 23, and subtracts from the charge already present on 22 thus increasing the gain, momentarily, of the system. The time constant of 22—21 is supposed to be slow with respect to the modulation. A reasonable value for this time constant is about $\frac{1}{10}$ second for phone signals. Circuit 23—24, however, represents a considerably lower resistance path (for the correct polarity) than 21; therefore, as far as the modulation is concerned the time constant of the whole circuit is less than $\frac{1}{10}$ second. Except in

the case of percussion instruments changes in modulation level are usually slow with respect to $\frac{1}{10}$ second.

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 a receiver of the type including an amplifier and an automatic volume control circuit therefor, said control circuit including a detector having a direct current voltage connection to the amplifier for varying the amplifier gain inversely with modulated carrier amplitude variation, a gain expansion network for the receiver comprising a path in shunt with a portion of said connection, said connection including a time constant resistor and capacity, and said path having a device of uni-lateral conductivity in shunt across the resistor for reducing the effect of said control circuit during deep modulation passages.

2. In a receiver of the type including an amplifier and an automatic volume control circuit therefor, said control circuit including a detector having a direct current voltage connection to the amplifier for varying the amplifier gain inversely with modulated carrier amplitude variation, a gain expansion network for the receiver comprising a path in shunt with a portion of said connection, said path comprising a diode in series with a resistor for reducing the effect of said control circuit during deep modulation passages.

3. In a receiver comprising a signal amplifier followed by a detector, an automatic gain control

connection from the detector to the amplifier for varying the amplifier gain inversely with modulated carrier amplitude variation, said connection including a time constant network, and a path in shunt with a resistive element of the network for reducing the effect of said control connection thereby expanding the amplifier gain in response to increase in modulation voltage amplitude.

4. A radio receiver of the type including a signal amplifier followed by a demodulator and having an automatic control gain connection to the amplifier for decreasing the amplifier gain in response to carrier amplitude increase, the improvement which includes a path operatively associated with a portion of the control connection, said path being constructed and arranged to decrease the control on the amplifier by said control connection in response to increasing modulation voltage amplitude, said path consisting of a diode in series with an adjustable resistor.

5. In a receiver of the type including an amplifier and an automatic volume control circuit therefor, said control circuit including a detector having a direct current voltage connection to the amplifier for reducing the amplifier gain in response to increase of modulated carrier amplitude, a gain expansion network for the receiver comprising a path in shunt with a portion of said connection, said path including a rectifier device arranged so as to feed into the direct current voltage connection a rectified portion of the detected modulation voltage, said rectified modulation voltage being of a polarity such as to increase the gain of said amplifier in response to deep modulation passages.

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