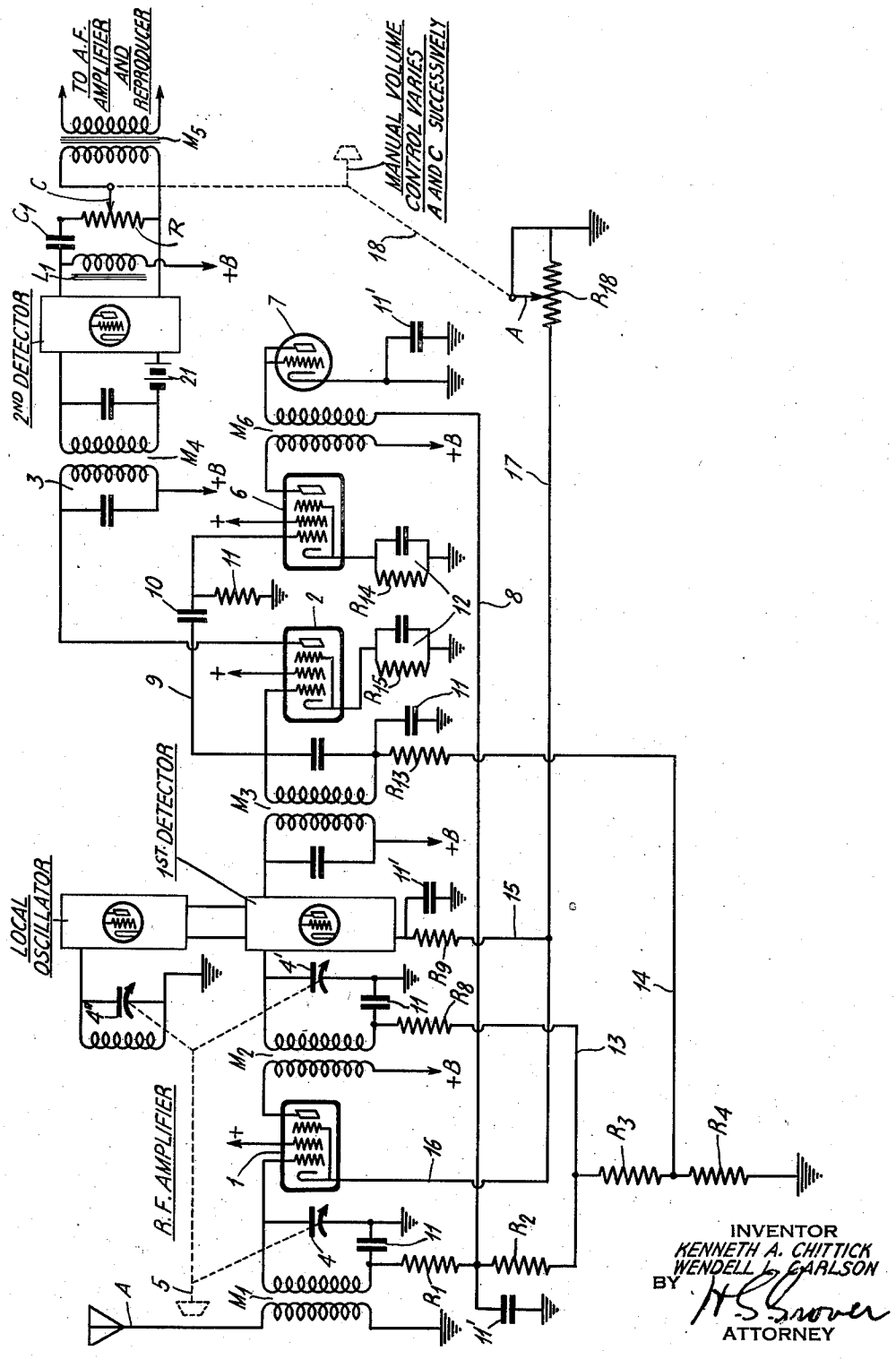
Sept. 21, 1937. K. A. CHITTICK ET AL 2,093,548

AUTOMATIC VOLUME CONTROL CIRCUIT

Original Filed Nov. 14, 1932



Patented Sept. 21, 1937 2,093,548

UNITED STATES PATENT OFFICE

2,093,548

AUTOMATIC VOLUME CONTROL CIRCUIT

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Original application November 14, 1932, Serial No. 642,544. Divided and this application January 26, 1935, Serial No. 3,546

12 Claims. (Cl. 250—20)

Our present invention relates to a radio receiver volume control circuit, and more particularly to a novel and improved type of manual volume control arrangement for a radio broadcast receiver, the present application being a division of our application Serial No. 642,544, filed November 14, 1932.

One of the main objects of the present invention is to provide in a radio receiver, as of the broadcast type, a compound manual volume control, the manual control functioning to reduce the radio frequency amplification about ten times during the first part of the control actuation, and subsequently regulating volume substantially entirely by variable audio frequency gain.

Another object of the invention is to provide in a radio receiver a manual volume control device which is adapted to predominantly vary the radio frequency amplification during the first part of its actuation from maximum to minimum volume, and subsequently to predominantly vary the audio frequency transmission throughout the remainder of the control actuation until the minimum volume point is obtained.

Another object of the invention is to provide in a radio receiver of the superheterodyne type equipped with an automatic volume control circuit which has a definite relation to the selectivity as well as the sensitivity of the receiver, a manual volume control instrumentality which functions to change the radio frequency and intermediate frequency amplification as well as the signal transmission between the second detector output and the audio frequency network.

Still other objects of the invention are to improve generally the simplicity and efficiency of volume control for radio receivers, and especially to provide a superheterodyne type of receiver which not only employs a highly efficient and reliable automatic volume control circuit, but also utilizes a manual volume control device which is economically manufactured and assembled in the receiver.

The novel features which we believe to be characteristic of our 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 we have indicated diagrammatically a circuit organization whereby our invention may be carried into effect.

Referring now to the accompanying drawing, wherein there is shown the circuit diagram of a superheterodyne receiver embodying the present invention, the superheterodyne broadcast receiver shown includes the usual grounded signal collector, or antenna, circuit A which is coupled, as at M_1, to the input electrodes of the first radio frequency amplifier tube 1, the latter tube being of the well known radio frequency pentode 58 type. The tube has its anode circuit coupled, as at M_2, to the input electrodes of the first detector, the latter being conventionally shown but it being clearly understood that the first detector tube may also be of the 58 type. The usual local oscillator circuit is conventionally represented, and its coupling to the first detector is schematically shown, the construction of the local oscillator and first detector circuits being well known to those skilled in the art, and a detailed explanation thereof being unnecessary for a proper understanding of the present invention.

The output of the first detector, which includes the desired intermediate frequency energy, is impressed, as at M_3, upon the input electrodes of the intermediate frequency amplifier tube 2, which may also be of the 58 type. The anode circuit of the tube 2, including the resonant output circuit 3, may be coupled, as at M_4, to the resonant input circuit of the second detector tube. The output of the second detector may be coupled, as at M_5, to one or more successive stages of audio frequency amplification followed by any desired type of reproducer, such as a loud speaker of the electrodynamic type.

The aforegoing general description of the essential components of a superheterodyne receiver are well known, and it is, additionally, well known to those skilled in the art that the rotors of the tuning condensers 4, 4′, 4″, may be mechanically coupled, in any well known manner, for manipulation by a uni-control device 5, shown in dotted lines. The condensers 4, 4′, and 4″ are arranged to resonate the input circuits of the radio frequency amplifier, the first detector, and the local oscillator respectively, it being noted that the rotors of each of these condensers are grounded. Again, the input circuit of the intermediate frequency amplifier tube is maintained fixedly tuned to the same intermediate frequency as the output circuit of the first detector and the output circuit of the intermediate frequency amplifier tube 2, and the input circuit of the second detector. The intermediate frequency may be maintained constant over the tuning range by using a means as disclosed in U. S. Patent 1,740,331 to W. L. Carlson of December 17, 1929.

The automatic volume control path includes the amplifier tube 6, preferably of the 58 or 57 type, and a tube 7, of the 56 or equivalent type, the tube 7 being arranged to function as a diode, or equivalent rectifier, by strapping the control electrode to the anode. The output electrode, comprising the strapped grid and anode, of tube 7 is connected by a lead 8 to the control grid circuits of the radio frequency amplifier tube 1, the first detector tube, and the intermediate frequency amplifier tube 2. The coupling between the anode circuit of amplifier 6 and the electrode circuit of tube 7, which coupling is designated by the reference character M_6, is relatively great so as to respond to a broad frequency band.

It will be now observed that the automatic volume control arrangement employed in the present invention comprises a branch circuit in parallel with the signal circuit, the grid of tube 6 being connected to the high potential side of the resonant input circuit of the intermediate frequency amplifier tube 2 through a path which includes the lead 9, the fixed condenser 10, the latter being also connected to ground through a resistor 11. The condenser 10 is preferably given a magnitude of about 300 mfd., and the resistor 11 is desirably given a magnitude of about 2 megohms. The usual direct current blocking condensers 11 are employed in each of the grid circuits of the controlled tubes, and there have also been shown the conventional self-biasing networks 12 in the grounded cathode legs of each of tubes 2 and 6.

It will now be pointed out that the present invention provides an automatic volume control which has a very definite relation to sensitivity and selectivity. The volume control tube itself is a rectifier of the two element type and has a special intermediate frequency amplifier stage to drive it. This volume control is more effective than volume control arrangements of the prior art. Due to its action the radio frequency voltage applied to the second detector is substantially constant for a signal of from 100 microvolts input to that of several volts. This regulation is obtained by effectively controlling the signal voltage beyond the point in the circuit where the automatic volume control is connected. The voltage to the automatic volume control tube however will not be constant. Such regulation in addition to being desirable from an entertainment viewpoint is also essential in this receiver due to the location of the manual volume control. Since there is no danger of overload on the second detector grid, the manual volume control C may therefore be located in the audio frequency circuit.

The automatic volume control network, in detail, comprises the lead 8 from the control tube 7, resistors R_1, R_2, R_3 and R_4, R_8, R_{13}; the lead 8 being connected intermediate the resistors R_1 and R_2. The grid circuit of the first detector stage is connected to a point intermediate the resistors R_2 and R_3 through a lead 13 which includes in series a resistor R_8. The grid circuit of the intermediate frequency amplifier tube is connected by a lead 14, and includes in series the resistor R_{13}, to a point intermediate the resistors R_3 and R_4.

The automatic volume control arrangement functions in the following manner: The input signal voltage for the intermediate frequency amplifier is additionally applied to the amplifier tube 6 due to the grids of both tubes being coupled together by means of the capacitor 10. The output of the intermediate frequency amplifier tube 2 is applied to the second detector through a sharply tuned transformer. However, the output of the volume control amplifier 6 is coupled to the volume control tube 7 through a broadly tuned transformer M_6. The location of the automatic volume control, and coupling it in this manner is due to two reasons.

In the first place, too much selectivity ahead of the automatic volume control is not desirable as it introduces excessive distortion and overload as a station is tuned in. However, a certain amount of selectivity is essential, otherwise the volume control will be caused to function by a local station when it is desired to tune in a weaker station on an adjacent channel. The increased selectivity beyond the automatic volume control in the signal circuit (transformer M_4) adds materially to the apparent selectivity as well as the actual selectivity because the automatic volume control action does not tend to overcome the reduction of signal strength to the second detector when tuning off resonance on transformer M_4.

The volume control tube 7 possesses a linear rectifier action by virtue of the strapping of the grid and plate. The drop across resistors R_2, R_3 and R_4 gives the bias for the radio frequency tube 1. The drop across resistors R_3 and R_4 comprises the grid voltage for the first detector, and that across resistor R_4, the grid voltage for the intermediate frequency amplifier tube 2. As the drop in these resistors is due to the signal voltage applied to the volume control tube 7, and this voltage is in turn dependent on the bias of the tube 1, first detector tube, and tube 2, an automatic action is obtained. The reason for the greater voltage applied to the radio frequency tube 1 and first detector than that applied to the intermediate frequency amplifier tube 2 is to further prevent overloading of these tubes on the side of a strong carrier.

The filter resistors R_8 and R_{13} preferably have a magnitude of about 100,000 ohms each, the blocking condensers 11, and the by-pass condensers 11' each having magnitudes of 0.1 mfd. For purposes of illustration it may be stated that the resistor R_1 may have a magitude of 500,000 ohms; the resistor R_2 may have a value of 400,000 ohms; the resistor R_3 may be 100,000 ohms; and the resistor R_4 may have a magnitude of 400,000 ohms. The resistor R_9 is connected in the cathode lead 15 of the first detector stage, the cathode lead 16 of the tube 1 being connected, with the lead 15, to a common lead 17 which is grounded through a resistor R_{18}.

One terminal of the resistor R_{18} is connected to an adjustable tap A which is adapted to function as a manual volume control device for the radio frequency section of the receiver. The tap A is mechanically coupled to the adjustable tap C of the audio frequency manual volume control resistor R by means shown in dotted lines, and designated by the reference numeral 18. The resistor R_9 furnishes self-bias for the grid of the first detector tube, and the resistor may have a magnitude of about 2,500 ohms, the resistor R_{14} which furnishes self-bias for the grid of the amplifier tube 6 having a magnitude of about 1,500 ohms, while the self-bias resistor R_{15} for the tube 2 may have a value of about 2,500 ohms. The radio frequency volume control resistor R_{18} may have a value of some 400 ohms.

The positive potential supply sources for the screen grids and anode of the tube 1, the first

detector tube, the tube 2, the tube 6 and the second detector tube are not shown. These potential sources are omitted to preserve simplicity of description, but it is understood that the conventional filtered output of a full wave rectifier associated with the usual commercial alternating current line may be employed for providing the necessary potentials for energizing the receiver circuits shown in Fig. 1.

The output of the second detector is arranged for coupling to the grid circuit of a succeeding audio frequency stage by means of impedance-transformer coupling. The plate potential supplied to the detector is fed through the coupling reactor L_1, and the audio component passes through the 0.5 mfd. coupling capacitor C_1. The manual audio volume control is located between the second detector and the succeeding audio frequency amplifier stage, and functions to reduce the voltage applied to the primary of the inter-stage transformer M_5. It is pointed out that the resistor R comprises only one section of the manual volume control 18.

Actually, there are two sections, the other being the resistor R_{18} between the radio frequency and first detector cathodes and varying the overall sensitivity. The control prevents all noises and signals of a very weak character from being received, and only functions over the last twenty degrees of the angular movement of the manual volume control. However, if such signals are desired it is only necessary to advance the volume control in the usual manner to its maximum position. In other words, the resistors R_{18} and R are arranged with respect to the common mechanical drive 18 so that the tap A during the first twenty degrees of adjustment varies the magnitude of the resistor R_{18}, and during the remainder of the adjustment of the manual drive 18 varies only the magnitude of the resistor R.

It should be noted that the automatic volume control plus the special intermediate frequency amplifier provides a radio frequency voltage on the second detector which is substantially constant between 9 and 12 volts for a signal of from 10 microvolts to several volts. With this arrangement, there is no danger of the second detector overloading, and accordingly, the volume control means may be placed in the audio frequency circuit. For the purpose of reducing the extreme sensitivity, the manual automatic volume control means operates for about 20 degrees in the radio frequency circuit to reduce the sensitivity to normal, then the audio frequency volume control becomes effective and the volume may be reduced to zero thereby. In other words, to adjust manually the volume from maximum to minimum, the resistor R_{18} is first introduced and then the resistor R, the reverse being the case to increase the volume from minimum.

Therefore, the main portion of the manual volume control is at the audio frequency end of the circuit. Hence, it will be seen that there is a definite relation between the operation and arrangement of the manual volume control and the functioning and construction of the automatic volume control, it being pointed out again that by virtue of the automatic volume control arrangement, the main portion of the manual volume control may be disposed at the audio frequency section of the radio receiver.

Noise between stations is effectively reduced without seriously compromising the automatic volume control by means of the compound manual volume control disclosed herein which functions to reduce the radio frequency gain about ten times during the first part of the control rotation, and later regulates volume entirely by variable audio gain. The noise between stations may be further reduced by employing a fixed bias on the second detector, represented merely for purposes of illustration by the source 21 in Fig. 1, substantially greater than the value usually employed. The automatic volume control circuit of Fig. 1 is characterized by its freedom from objectionable time lag; freedom from distortion of the low audio frequencies; and its lack of susceptibility to flutter or motor-boating.

While we have indicated and described a system for carrying our invention into effect, it will be apparent to one skilled in the art that our 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 our invention, as set forth in the appended claims.

What we claim is:

1. In combination with a high frequency amplifier whose gain is to be controlled, a rectifier for the high frequency amplifier output, means for coupling the high frequency amplifier to the rectifier input, a device of asymmetric conductivity, a second high frequency amplifier coupled to said device, means for coupling the output of the first amplifier to the input of the second amplifier and an automatic volume control arrangement including a direct current potential connection between said device and a gain control electrode of said first amplifier, means for adjusting the magnitude of the output of the rectifier, means for adjusting the conductivity of the first amplifier, and a common manually operable means for controlling both said adjusting means in a predetermined successive manner to supplement the action of said volume control arrangement when receiving substantially no signals.

2. In a radio receiver of a type including a radio frequency amplifier, a detector provided with a high negative grid bias, an audio frequency amplifier and an automatic volume control arrangement for maintaining the signal input to the detector substantially constant between 9 and 12 volts for a signal of from 10 microvolts to several volts, a compound manual volume control device for reducing noise between stations without substantially affecting the action of said automatic control, said device including a resistor in the radio amplifier space current path, a resistor coupling the detector and audio amplifier, and means for successively varying the operative values of said resistors.

3. In a radio receiver of a type including a radio frequency amplifier, a detector, an audio frequency amplifier and an automatic volume control arrangement for maintaining the signal input to the detector substantially constant over a relatively wide range of signal voltage variation, a compound manual volume control device for reducing noise between stations without substantially affecting the action of said automatic control, said device including a resistor in the radio amplifier space current path, a resistor coupling the detector and audio amplifier, and means for successively varying the operative values of said resistors, the resistors being so related that variation of the first resistor results in a decrease of gain of said radio amplifier of about ten times.

4. In a radio receiver of a type provided with a tuned radio frequency amplifier, a demodulator and an audio frequency utilization network,

means for varying the gain of the radio frequency amplifier, means for varying the transmission of demodulated signal energy between the demodulator and said utilization network, and a manually adjustable means for regulating the adjustments of said two varying means in a manner such that the radio frequency amplifier gain is predominantly varied during a portion of the actuation of said manually adjustable means, and the demodulated signal transmission is predominantly varied during the remaining portion of the actuation of the manually adjustable means.

5. In a radio receiver of a type provided with a tuned radio frequency amplifier, a demodulator and an audio frequency utilization network, means for varying the gain of the radio frequency amplifier, means for varying the transmission of the demodulated signal energy between the demodulator and said utilization network, and a manually adjustable means for regulating the adjustments of said two varying means in such a manner that the radio frequency amplifier gain and said demodulated signal transmission are successively varied.

6. In combination, a tuned radio frequency amplifier, a detector, an audio frequency amplifier, a manual volume control device including a variable resistor disposed in the cathode circuit of said radio frequency amplifier, a variable resistor being connected across the demodulator output, and a common adjusting means mechanically coupled with said two variable resistors for controlling the adjustments made thereto in a predetermined successive order.

7. In a superheterodyne receiver of the type including at least one tuned radio frequency amplifier, a first detector, second detector and a following audio frequency utilization network, a volume control device comprising means for varying the potential difference between the input electrodes of said radio frequency network, said means similarly being arranged to vary the potential difference between the input electrodes of said first detector, means for varying the signal transmission efficiency between the second detector and said utilization network, and a manually adjustable device mechanically coupling said two means in such a manner as to regulate the adjustments made thereto in a predetermined successive order.

8. In a radio receiver provided with a high frequency amplifier whose gain is to be controlled and a rectifier for the high frequency amplifier output, means for adjusting the magnitude of the output of the rectifier, means for adjusting the gain of said amplifier, and a common manually operable means for controlling both said adjusting means in a predetermined successive manner.

9. In a radio receiver of a type including a radio frequency amplifier, demodulator and an audio frequency amplifier, a compound manual volume control device for reducing noise between stations, said device including a resistor in the radio frequency amplifier space current path, a resistor coupling the demodulator and audio amplifier, and means for successively varying the operative values of said resistors.

10. In a radio receiver of a type including a radio frequency amplifier, a detector and an audio frequency amplifier, a manual volume control device for reducing noise between stations, said device including a resistor in the radio frequency amplifier space current path, a resistor coupling the detector and audio amplifier, and means for successively varying the operative values of said resistors, the resistors being so related that variation of said last means during substantially the first 20° of its adjustment varies solely the magnitude of said first resistor, and during the remainder of the adjustment thereof varies solely the magnitude of the said second resistor in order to reduce the sensitivity of the receiver from maximum to minimum.

11. In a superheterodyne receiver of the type including a radio frequency amplifier, frequency changer, intermediate frequency amplifier, second detector and means for tuning the radio amplifier and frequency changer to select different signal carrier frequencies, an automatic volume control network including a diode rectifier, and a direct current potential connection between the rectifier anode and an input electrode of at least each of said two amplifiers, a selective network between said intermediate amplifier output and the second detector, a second selective network between the intermediate amplifier input and the diode, both said selective networks being tuned to the intermediate frequency, the selectivity of the first network being sufficiently greater than that of the second network to minimize overloading of the second detector on the side of a strong signal carrier frequency when tuning the receiver through a carrier frequency, and a manual volume control device arranged to supplement the automatic volume control network for the reduction of undesired noises when tuning between carrier frequencies, said device including a single adjustable resistive means for successively varying the gain of said radio amplifier and the second detector output.

12. In a wave transmission system of the type provided with a wave transmission tube feeding a demodulator, the improvement which comprises a device for adjusting the gain of the transmission tube, a second device for adjusting the magnitude of the demodulator output, and a common means for regulating the adjustments of said two devices in a predetermined successive order such that the said gain is predominantly varied during a portion of the actuation of the common means, and the demodulator output magnitude is predominantly varied during another portion of the actuation of the said common means.

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