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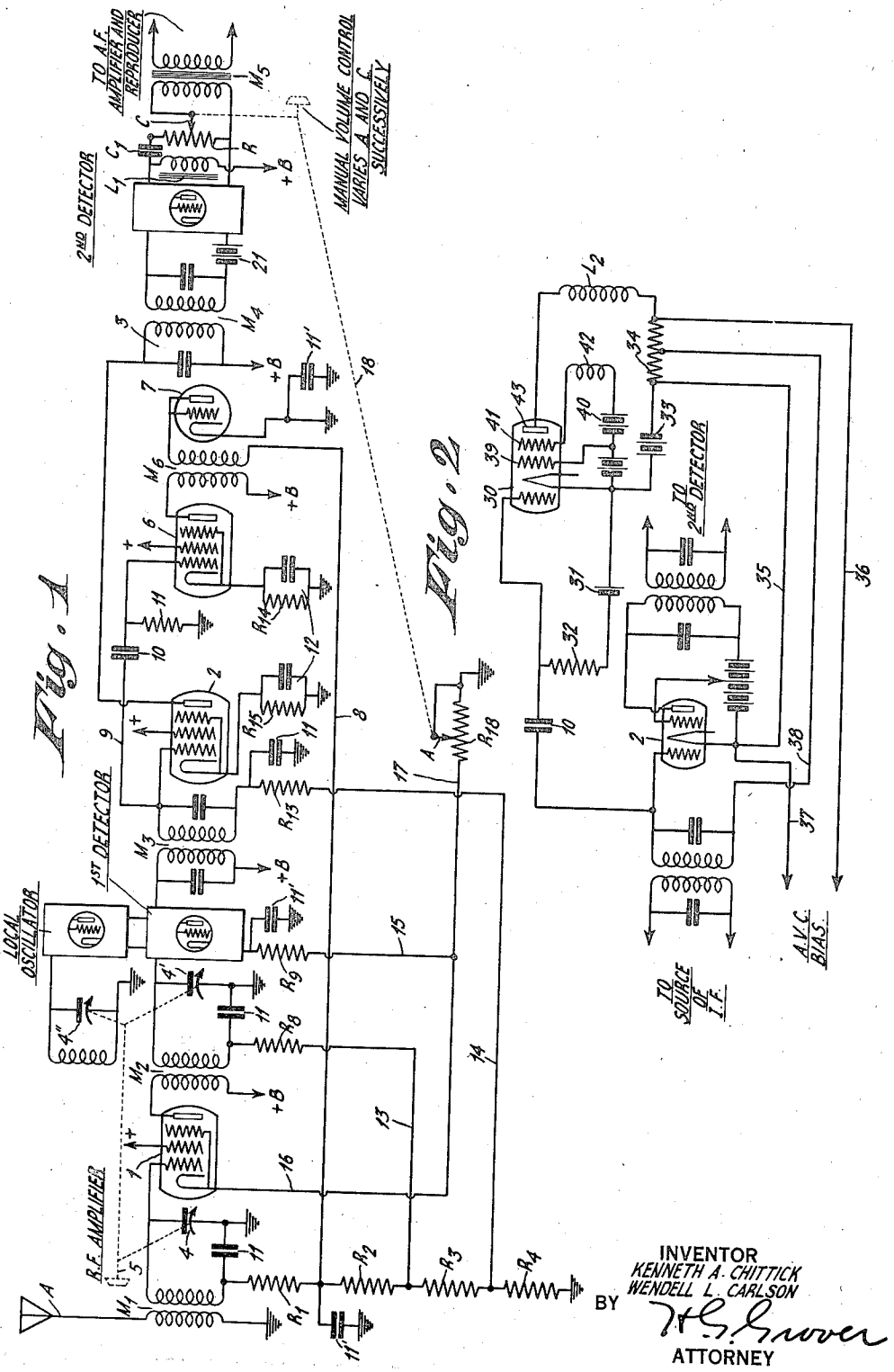


Fig. A

Fig. 2

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AUTOMATIC VOLUME CONTROL CIRCUITS

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The present invention relates to radio receiver control circuits, and more particularly to novel and improved types of automatic volume control circuits for radio broadcast receivers.

One of the prime objects of the present invention is to provide an automatic volume control arrangement, for use in a broadcast receiver, which has a very definite relation to the selectivity as well as the sensitivity of the receiver, there being less selectivity to the automatic volume control circuit than to the audio detector with the result that overloading on the side of strong carriers (when tuning through a carrier) is reduced.

Another object of the invention is to provide a circuit wherein the automatic sensitivity control action is less for the complete automatic control circuit than for the signal circuit through to the audio detector which allows more complete automatic control than otherwise possible.

According to the present invention the automatic volume control tube is operated in conjunction with an input amplifier, or branch, circuit, in parallel with the signal circuit, which amplifier or branch circuit is not controlled by the automatic volume control voltage itself while the equivalent intermediate frequency branch signal circuit is controlled by the automatic control voltage whereby a flat or drooping automatic volume control characteristic may be obtained.

Still another object of the invention is to effectively reduce noise between stations without seriously compromising the automatic volume control, a compound manual volume control being employed, the manual control functioning to reduce the radio frequency and intermediate frequency gain about ten times during the first part of the control actuation, and subsequently regulating volume entirely by variable audio frequency gain.

Another object of the invention may be stated to comprise the provision of an automatic volume control circuit for a superheterodyne type of receiver wherein the control circuits divide from the sound channel at the grid of the last intermediate frequency stage, the volume control circuit consisting of an intermediate frequency amplifier and a diode rectifier or the equivalent, providing a radio frequency voltage on the second or audio detector which is substantially constant between 9 and 12 volts for a signal of from 10 microvolts to several volts, the volume control circuit being further characterized by the fact that it is free from objectionable time lag, does not distort the low audio frequencies, and is not susceptible to flutter or motor boating.

Still other objects of the invention are to improve generally the simplicity and efficiency of automatic volume control arrangements for radio receivers, and to especially provide a superheterodyne type of receiver which employs an automatic volume control circuit which is not only durable and reliable in operation, but has a definite relation to sensitivity and selectivity, and is moreover 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 several circuit organizations whereby our invention may be carried into effect.

In the drawing,

Fig. 1 diagrammatically shows a superheterodyne type of receiver employing the present invention,

Fig. 2 shows a modified form of the invention.

Referring now to the accompanying drawing wherein like reference numerals designate similar elements in the different figures, there is shown in Fig. 1 a superheterodyne broadcast receiver which 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 mmfd., 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 grid networks 12 in the grounded cathode legs of each of tubes 2 and 6.

It may 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, four 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, but 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 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 straight 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 resistor 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 magnitude 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 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 interstage 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 over-all sensitivity. This 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 discussed above 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.

In Fig. 2 there is shown a modification of the automatic volume control arrangement shown in Fig. 1 wherein the functions of tubes 6 and 7 of Fig. 1 are combined in a single tube 30. The tube 2, as in the case of Fig. 1, is the intermediate frequency amplifier tube, and the grid of the multiple duty tube 30 is connected to the grid side of tube 2 through the coupling capacitor 10. The grid of tube 30 is maintained negatively biased by means of a path from the cathode, which path includes the negative biasing source 31 and the resistor 32.

The anode of tube 30 is connected to the negative side of a potential source 33 through a path which includes the inductance L_2, and the resistor 34. One side of the resistor 34 is connected by lead 35 to the negative side of the cathode of the tube 2, while the other terminal of resistor 34 is connected by a lead 36 to the intermediate frequency circuits to be controlled, a lead 37 connected to the negative leg of the cathode of tube 2 similarly being adapted for connection to the controlled radio frequency circuits. An intermediate point of resistor 34 is connected by lead 38 to the grid circuit of tube 2.

A cold control electrode 39 of tube 30 is connected to a point of less positive potential on a potential source 40 than the point to which the cold electrode 41 is connected, the electrode 41 being connected to the high potential side of source 40 through an inductance 42. Inductance 42 and L_2 are equivalent to M_6 in Fig. 1. Grid 41 acts as the plate of a four element tube and plate 43 acts as a diode anode. The tube 30 and its

associated circuits perform the combined functions of tubes 6 and 7 of Fig. 1. That is to say, it functions as an amplifier of a portion of the intermediate frequency energy delivered to the tube 2, and also as an automatic volume control tube for the radio frequency circuits. The signal energy is amplified in the electronic section including the cathode and the three grids. The coil 42 passes the amplified energy to coil L_2. The energy is rectified in the diode circuit including the cathode and plate 43.

While we have indicated and described several systems 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 organizations 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, in a superheterodyne receiver, a radio frequency amplifier, a frequency changer circuit, an intermediate frequency amplifier, a second frequency changer circuit, a rectifier control tube, a third amplifier having its output coupled to said rectifier through a coupling broadly tuned to the operating intermediate frequency of the receiver, means for coupling an input electrode of the third amplifier to the input circuit of the intermediate frequency amplifier, a path, sharply resonant to the said intermediate frequency, coupling an output electrode of the intermediate frequency amplifier to the input of the second frequency changer circuit, and a direct current path between an output electrode of the control rectifier and the radio frequency amplifier, the first frequency changer circuit and the intermediate frequency amplifier, said path including means whereby said last named three circuits are biased in a progressively decreasing manner.

2. In combination, in a superheterodyne receiver, a radio frequency amplifier, a frequency changer circuit, an intermediate frequency amplifier, a second frequency changer circuit, a rectifier control tube, a third amplifier having its output coupled to said rectifier through a coupling broadly tuned to the operating intermediate frequency of the receiver, means for coupling an input electrode of the third amplifier to the input circuit of the intermediate frequency amplifier, a path, sharply resonant to the said intermediate frequency, coupling an output electrode of the intermediate frequency amplifier to the input of the second frequency changer circuit, and a direct current path between an output electrode of the control rectifier and the radio frequency amplifier, the first frequency changer circuit and the intermediate frequency amplifier, said path including means whereby said three last named circuits are differentially biased, said third amplifier and control rectifier tube comprising an automatic volume control arrangement providing a radio frequency voltage on the second frequency changer circuit which is substantially constant between 9 and 12 volts for a signal of from 10 microvolts to several volts, and a manual volume control device in the output of the second frequency changer circuit adapted to control the output of the receiver when the latter is tuned between desired signal frequencies without danger of overloading of the second frequency changer circuit.

3. 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 connection between the rectifier anode and an input electrode of each of said two amplifiers and said frequency changer, 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.

4. 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 connection between the rectifier anode and an input electrode of at least one of said two amplifiers, a selective network between said intermediate amplifier output and the second detector, a second selective network including an amplifier 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.

5. In a radio receiver including a signal amplifier and a detector, a signal coupling network between the amplifier and detector, an automatic volume control circuit for the amplifier comprising a rectifier whose rectified output regulates the gain of the amplifier, a second signal coupling network between the amplifier and the rectifier, the selectivity of the first network being sufficiently greater than that of the second network to minimize overloading of the detector on the side of a strong received signal carrier.

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