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AUTOMATIC TONE CONTROL CIRCUIT

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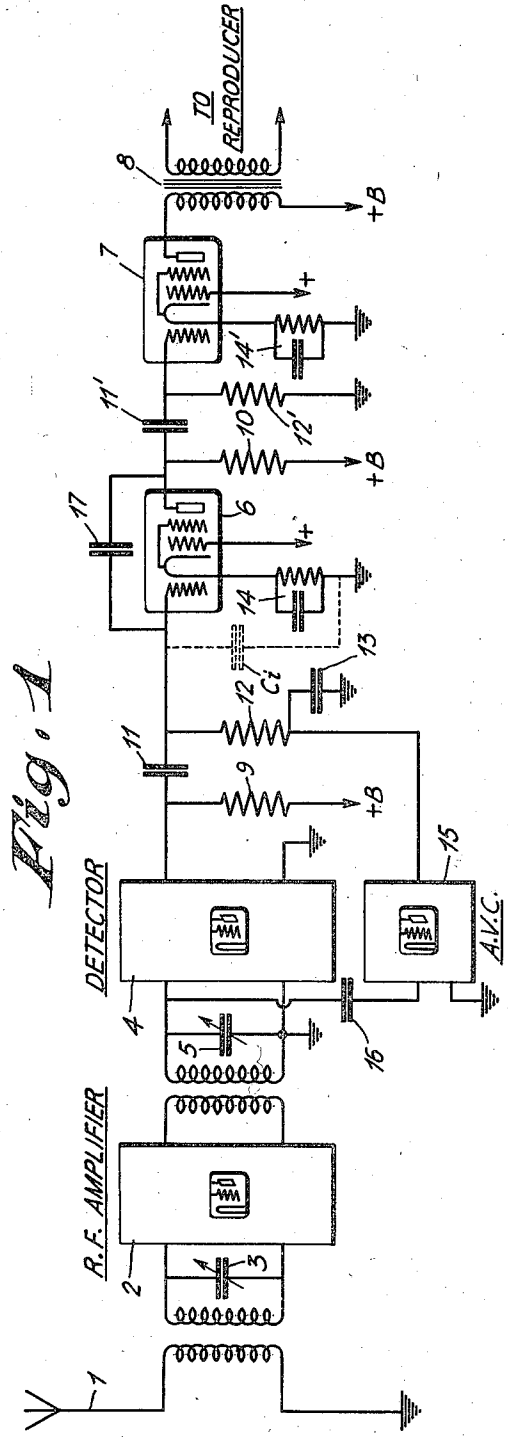


Fig. 1

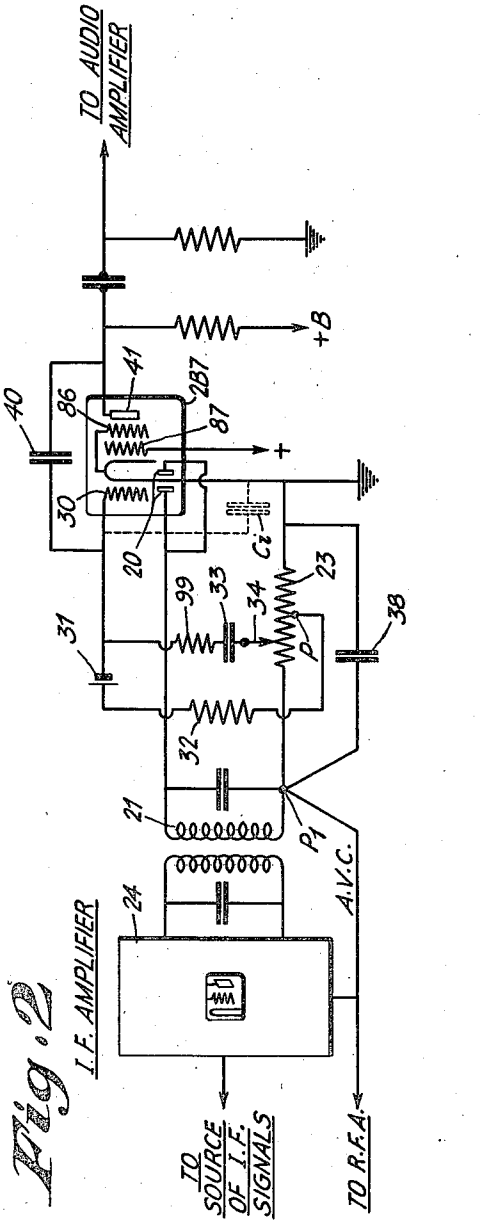


Fig. 2

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AUTOMATIC TONE CONTROL CIRCUIT

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13 Claims. (Cl. 250—20)

My present invention relates to control circuits for radio receivers, and more particularly to automatic control circuits for audio frequency amplifiers.

In my co-pending application, Serial No. 638,514, filed October 19th, 1932, Patent No. 2,017,270, October 15, 1935, there has been disclosed a method of regulating the transmission of the higher audio frequencies in an audio frequency amplifier circuit, which method comprises the variation of the grid potential of an electronic discharge tube to vary the effective grid to cathode capacity of the tube, the variable input capacity being employed as an adjustable audio frequency attenuation path. As explained in the said application, the tone control, or attenuation control, can be provided by utilizing an auxiliary tube in the audio frequency amplifier network, which regulates the audio-frequency transmission characteristic. In the case of a radio receiver the grid circuit of the tone control tube is connected to a source of automatic volume control potential so that at the no-signal condition of the receiver the attenuation of the higher audio frequencies is a maximum, whereby the transmission of undesired background noise impulses is substantially prevented.

It is sometimes permissible to automatically regulate the volume of a receiver by control of an audio frequency amplifier of the receiver. In such a case the need for an auxiliary tone control tube of the type disclosed in my aforesaid application is simultaneously eliminated. Accordingly, it may be stated that it is one of the main objects of my present invention to provide a variable attenuation device for an audio frequency amplifier, which device comprises a voltage operated capacity, without utilizing any tube other than the tubes employed for the audio frequency amplifier.

Another important object of the invention is to provide an automatic tone control mechanism for an audio frequency amplifier, the tone control being secured by varying the inherent grid to cathode capacity of one of the audio frequency amplifier tubes, and the capacity being regulated by adjusting the grid voltage of the said one tube in response to signal carrier amplitude variations.

Another object of the invention is to provide a radio receiver which has its detector resistively coupled to an audio frequency amplifier, the grid voltage of the amplifier being varied in response to variations in the flow of direct current through the resistance coupling whereby the inherent grid to cathode capacity of the amplifier is regulated to function as an automatic audio frequency attenuation element.

Still other objects of the invention are to improve generally frequency discrimination networks adapted for use with audio frequency amplifiers, and to particularly provide a voltage operated tone control condenser for use in conjunction with a resistance coupled audio frequency amplifier which is not only reliable in operation, but readily assembled in a radio 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 several circuit organizations whereby my invention may be carried into effect.

In the drawing:—

Fig. 1 diagrammatically shows a receiver circuit embodying the present invention.

Fig. 2 shows a modified form of the invention.

Referring now to the accompanying drawing, wherein like reference characters in the two figures represent similar circuit elements, it is pointed out that in Fig. 1 there is shown a purely conventional type of radio receiver wherein the signal collector 1 is coupled to a tunable radio frequency amplifier 2, the tuning means of the amplifier being generally represented by the numeral 3. The detector 4 of the receiver is coupled to the output of the amplifier 2, and the tuning means of the detector is designated by the numeral 5. The demodulated output of the detector 4 is transmitted by resistance-condenser coupling to the first audio frequency amplifier tube 6, of the pentode type, and the amplified output of tube 6 is transmitted through a second resistance-condenser coupling to the second audio frequency amplifier 7. The amplified output of tube 7 may be transmitted through an audio frequency transformer 8 to any well known type of reproducer.

The plate of the detector tube 4 is connected to a proper positive potential source B through a resistor 9, and the resistor 10 connects the plate of tube 6 to a proper positive potential point on the same source B. Of course, as is well known to those skilled in the art, the source B may be the usual bleeder across the filter output of the alternating current rectifier, or a commercial direct current source may be utilized. The

coupling condenser 11 transfers the audio frequency component of the plate current of detector 4 to the grid circuit of audio amplifier tube 6, the coupling resistor 12 being connected between the grid side of condenser 11 and the automatic volume control network of the receiver. The by-pass condenser 13 connects the volume control side of resistor 12 to ground, and the usual self-biasing network 14 is disposed in the grounded cathode circuit of tube 6. The coupling condenser 11' couples the plate of tube 6 to the grid of tube 7, while the resistor 12' is connected between ground and the grid side of condenser 11', the self-biasing network 14' performing the same function as was stated in connection with network 14.

The automatic volume control network, designated in Fig. 1 by the symbol "AVC", is schematically shown as being connected between one side of resistor 12 and the input circuit of the detector 4. Such a volume control network usually embodies a rectifier, conventionally represented by the numeral 15, signal energy being impressed upon the rectifier from the input circuit of detector 4 through the signal path including condenser 16. The details of the construction of the automatic volume control network are not necessary to a proper understanding of the present invention, since those skilled in the art of constructing radio broadcast receivers employing automatic volume control are well acquainted with such circuit details. It is merely sufficient to point out that the direct current component of the rectified output of rectifier 15 is utilized to vary the negative grid bias of tube 6.

As explained in my aforementioned co-pending application, the input condensive impedance of the tone control tube may be varied in magnitude by varying the grid bias of the tube. C_i, the input condenser impedance of tube 6, is represented by dotted lines in Fig. 1. The input conductive impedance of tube 6 is a function of the tube mutual conductance G_m, the grid-plate capacitance C_{gp}, and the nature of the load in the plate circuit of tube 6. By augmenting C_{gp}, as by employing external capacitance 17, and by using a suitable load in the plate circuit of tube 6, high values of C_i may be reached. The magnitude of the input capacity C_i may be controlled by varying the G_m of the tube 6, as for example by altering the bias applied to the grid of the tube. It can be shown that the value of C_i is approximately $(A+1)\ C_{17}$, where A equals the amplification of the tube.

From this expression it will be seen that the network including tube 6 actually functions as a voltage operated condenser, and performs electrically as if a variable condenser, having a range of values equal to the range of C_i, were connected in shunt between the grid and the ground side of the cathode of tube 6. When the G_m of tube 6 is varied so as to increase the amplification, as by decreasing the negative bias applied to the grid of tube 6, the electrical effect is equivalent to increasing the magnitude of C_i shunted between the grid and ground.

The source of variable grid potential in Fig. 1 comprises a source of potential which varies in accordance with the source of audio frequency energy. The tube 6 not only functions as an audio frequency amplifier tube, but in addition is employed as a background noise suppressor device in conjunction with the automatic volume control system of the receiver. By applying the volume control potential to the grid circuit of tube 6, the G_m of the latter varies simultaneously with the receiver gain so that at high volume control potentials, when the receiver gain is low as on local reception, the value of C_i is a minimum. When weak signals are received the amplification of tube 6 will be a maximum, and hence background noise impulses will be greatly amplified. However, due to the fact that the magnitude of C_i is a maximum, the higher audio frequencies will be shunted to ground. That this action will take place is obvious, since the capacity C_i is connected in shunt with the resistor 12. A considerable portion of the background noises resides in the higher audio frequency portion of the audio spectrum, these noise components being the most objectionable, and hence attenuation of the higher audio frequencies substantially suppresses the reproduction of the undesired background noise impulses.

It will now be seen that advantage has been taken of the fact that the automatic volume control action is applied to a resistance coupled audio frequency amplifier stage. It has been determined that the grid bias of a resistance coupled audio frequency amplifier utilizing a high impedance pentode can be varied over a range adequate to vary the gain 4—6 fold, without causing intolerable audio distortion. It is for this reason that the automatic volume control bias can be applied within limits to the grid of the audio amplifier tube 6. By augmenting the capacity C_i by means of the condenser 17 it is then possible to automatically attenuate the higher audio frequencies as the gain of the audio amplifier tube 6 is varied. It will, therefore, be seen that the automatic tone control is made inherent in the gain controlled audio frequency amplifier stage, thus eliminating the need for an auxiliary tone control tube.

Of course, the invention is not limited in any way to the type of receiver shown in Fig. 1. For example, the network 2 may comprise the usual radio frequency amplifier, first detector, local oscillator network and intermediate frequency amplifier stage usually employed before a second detector stage in a superheterodyne receiver. In that case the detector 4 serves as the second detector stage.

In Fig. 2 there is shown the application of the present invention to a superheterodyne type of receiver which employs a multi-function tube 2B7 as a composite second detector-audio frequency amplifier stage. The specific construction of tube 2B7 need not be explained in detail, since it is known to those skilled in the art as a duplex diode-pentode tube of the 2B7 type. T. M. Shrader has described the construction of a tube similar to tube 2B7, that is, with the suppressor grid 86 and the screen grid 87 omitted, in his application Serial No. 622,140, filed July 12, 1932, Patent No. 2,058,834, October 27, 1936. In the Shrader application there has also been described the utilization of diode section of the tube as a signal rectifier, and the triode section of the tube as an amplifier of the audio component of the rectified signal energy. In the case of Fig. 2 the diode anodes 20 are strapped together and are connected to the ground cathode through a path which includes in series the tuned signal input circuit 21 and the resistor 23. The circuit 21 is coupled to the intermediate frequency amplifier 24, and the diode rectifier circuit develops a rectified signal voltage across resistor 23.

The control grid 30 of the pentode section of

tube 2B7 is connected to point P through a path which includes in series the fixed, or minimum, control grid bias source 31 and the high value resistor 32. The audio component of the rectified signal energy is applied to the control grid 30 through a path which includes the resistor 99, the audio signal by-pass condenser 33 and the adjustable tap 34. The automatic volume control lead for the high frequency amplifiers whose gain is to be controlled is connected to the point P_1 of resistor 23. The source 31 provides an initial fixed bias for the control grid 30, and when signals are received the effective negative bias of the control grid 30 depends upon the variation in intensity of the direct current component of the rectified signal, a portion of the developed voltage as at P being applied to 30.

It will, therefore, be seen that the pentode amplifier section of tube 2B7 is resistance-condenser coupled to the signal rectifier diode section of the tube. The grid bias of the pentode audio amplifier section of tube 2B7 is, therefore, varied in response to variations in the received signal carrier amplitude. The point P is chosen so as to prevent excessive automatic volume control action of the pentode audio amplifier section of tube 2B7. The tap 34 provides a manual volume control of the audio amplifier section of tube 2B7, and it is to be clearly understood that the tap 34 may be adjusted on resistor 23 so that the entire audio component developed across resistor 23 may be applied to the audio amplifier section of tube 85.

Resistor 99 is added in series with condenser 33 since it affords a greater control effect, the capacity C_1 causing a drop in resistor 99 when C_1 is large and having negligible effect when C_1 is small. It is a means of spoiling the regeneration of the audio source. The resistor 99 has a small magnitude, about one tenth that of resistor 23.

To secure the automatic tone control action of the pentode audio amplifier section the augmenting condenser 40 is connected between the grid 30 and the plate 4. The inherent grid to cathode capacity of the amplifier section of tube 2B7 is shown by dotted lines, and it is to be clearly understood that this inherent capacity C_1 functions as a high audio frequency attenuation path in the same manner as was explained in connection with Fig. 1. It is also to be noted that the attenuation effect increases not only as the automatic volume control action on grid 30 is operative, but also with adjustment of the manual volume control tap 34, since at low values of audio intensity level the capacity C_1 shunts a lower resistance and has less effect.

It will also be recognized that in Fig. 2 there is not only provided automatic tone control of the audio frequency amplifier with automatic volume control of the audio amplifier, but there is additionally included automatic volume control of the radio frequency amplifier portion of the receiver. Both in Figs. 1 and 2 the automatic tone control path functions to cut off the higher audio frequencies, or decrease the fidelity of reproduction of the receiver, when signals of weak carrier intensity are received. This is of value in receiving weak distant stations, since the background noises are substantially suppressed. Of course, when strong local stations are received, and when maximum fidelity of reproduction is desired, the higher audio frequencies are not attenuated appreciably.

The plate 41 of the pentode section of tube 2B7 is shown as arranged for resistance coupling to a subsequent stage of audio frequency amplification, but it is to be clearly understood that it is within the scope of the present invention to replace the resistance coupling by any equivalent type of coupling, consistent with gain and suitable automatic input capacity variation. Further, the embodiment shown in Fig. 2 is not limited to a superheterodyne receiver, but may be employed in connection with a tunable radio frequency amplifier network in place of the intermediate frequency amplifier 24.

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 I claim is:—

1. An audio frequency amplifier of variable gain, means responsive to variations in intensity of the currents impressed on the amplifier for providing said variable gain, and means for augmenting the inherent input capacity of said amplifier whereby the latter varies automatically with the gain and directly therewith.

2. An audio frequency amplifier of variable gain, means for providing said variable gain, and condensive means for augmenting the inherent input capacity of said amplifier whereby the latter varies automatically with the gain and directly therewith.

3. In combination with a signal demodulator, an audio frequency amplifier of variable gain, resistance-capacity coupling between said demodulator and amplifier, means responsive to variations in intensity of the currents impressed on the amplifier for providing said variable gain and means for augmenting the inherent input capacity of said amplifier whereby the latter varies automatically with the gain and directly therewith.

4. An audio frequency amplifier of variable gain, means for providing said variable gain, and means for augmenting the inherent input capacity of said amplifier whereby the latter varies automatically with the gain and directly therewith, and said first means including a signal rectifier resistively coupled to said amplifier.

5. An audio frequency amplifier of variable gain, means for providing said variable gain, and means for augmenting the inherent input capacity of said amplifier whereby the latter varies automatically with the gain and directly therewith, a signal demodulator, means for resistively coupling the demodulator to the input electrodes of said amplifier, and a single tube envelope housing said demodulator and amplifier.

6. An audio frequency amplifier of variable gain, means for providing said variable gain and means for augmenting the inherent input capacity of said amplifier whereby the latter varies automatically with the gain and directly therewith, a diode detector for rectifying impressed signals, means for resistively connecting the control grid of said amplifier to a point of direct current potential of said diode detector, means for impressing the audio frequency component of the rectified signal energy upon said control grid, and a single tube housing said diode detector and amplifier.

7. An audio frequency amplifier of variable gain, means for providing said variable gain, and

means for augmenting the inherent input capacity of said amplifier whereby the latter varies automatically with the gain and directly therewith, a signal detector, means resistively coupling the detector to the input electrodes of said amplifier, an automatic volume control means for producing said variable gain, and a condenser connected between the control grid and anode of said audio amplifier for augmenting said inherent input capacity.

8. In a radio receiver including a detector and an audio amplifier, resistive means coupling the detector output to the audio amplifier input, an automatic volume control for the receiver comprising means, responsive to received signal intensity variations, connected to the said amplifier for varying the gain thereof, and means operatively associated with the amplifier for causing substantial variations in audio amplifier input capacitance when the control means is operative.

9. In a receiver of the type including at least a radio amplifier, a signal demodulator and audio amplifier, automatic volume control means for regulating the gain of the radio amplifier to maintain the signal input to the demodulator substantially constant, resistive means coupling the demodulator and audio amplifier, means, responsive to received signal variations, for varying the audio amplifier gain in the same sense as the radio amplifier gain, means for augmenting the inherent input capacity of the audio amplifier whereby variation of the audio amplifier gain results in variation of said capacity in the same sense.

10. In a radio receiver including a demodulator and an audio frequency amplifier, means responsive to received signal carrier amplitude variations for varying the gain of said amplifier, and means operatively associated with amplifier for causing substantial variations in the amplifier input capacitance when the said gain varying means is operative.

11. In combination with a source of waves of a band of frequencies, a wave transmission tube comprising at least a cathode, wave input electrode and an output electrode, means coupling the cathode and input electrode to said source whereby said waves are repeated in the tube output electrode circuit, the constants of the tube circuit being chosen to provide a substantial capacity between the cathode and input electrode, and means, responsive to amplitude variations in said waves, for varying a constant of said tube circuit in a sense to cause the magnitude of said capacity to change inversely with the amplitude of said waves.

12. In combination with the demodulator of a radio receiving system, an audio amplifier tube having its input electrodes coupled to the demodulator circuit to derive audio energy therefrom, said amplifier tube having means providing a substantial capacity of low impedance to the higher audio frequencies between its input electrodes, and a single means for regulating the gain of the audio amplifier and the efficiency of transmission of the higher audio frequencies through said capacity.

13. In combination with a source of audio modulated signal energy, a diode rectifier circuit including a resistive impedance across which is developed audio voltage, an audio repeater tube having its cathode connected to one side of the impedance, a capacitative path connected between the tube cold input electrode and said impedance, said repeater having a capacity of low impedance to the higher audio frequencies of said voltage between the cathode and input electrode, and means for adjusting the path connection to the rectifier impedance for simultaneously controlling the audio voltage impressed on the repeater tube and varying the transmission of the said higher audio frequencies through said capacity.

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