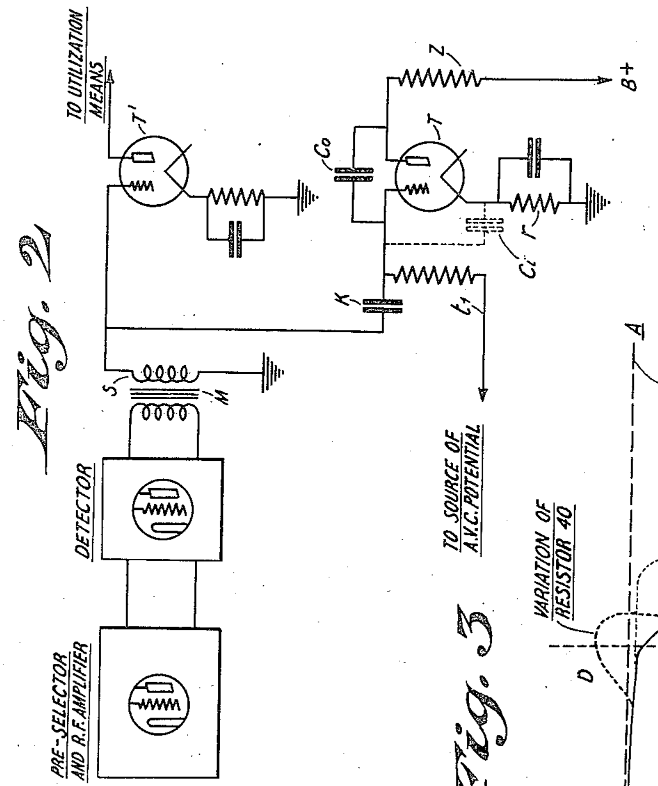
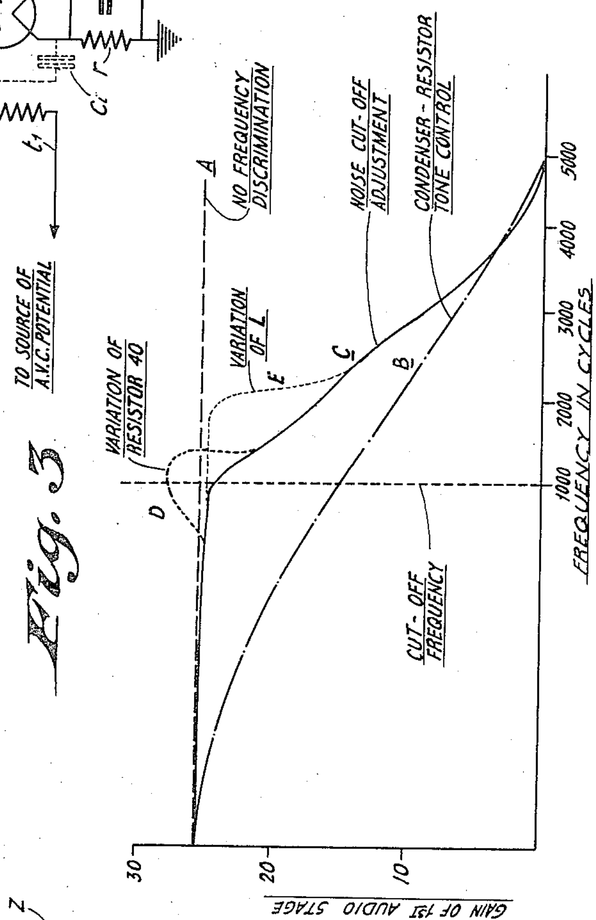
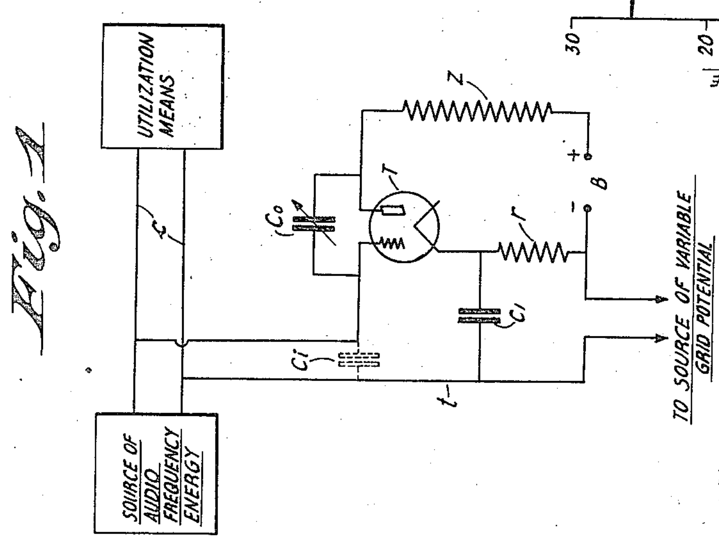
Oct. 15, 1935. J. YOLLES 2,017,270

ELECTRONIC TONE CONTROL

Filed Oct. 19, 1932 2 Sheets-Sheet 1







INVENTOR-
JACOB YOLLES
BY H. S. Grover
ATTORNEY-

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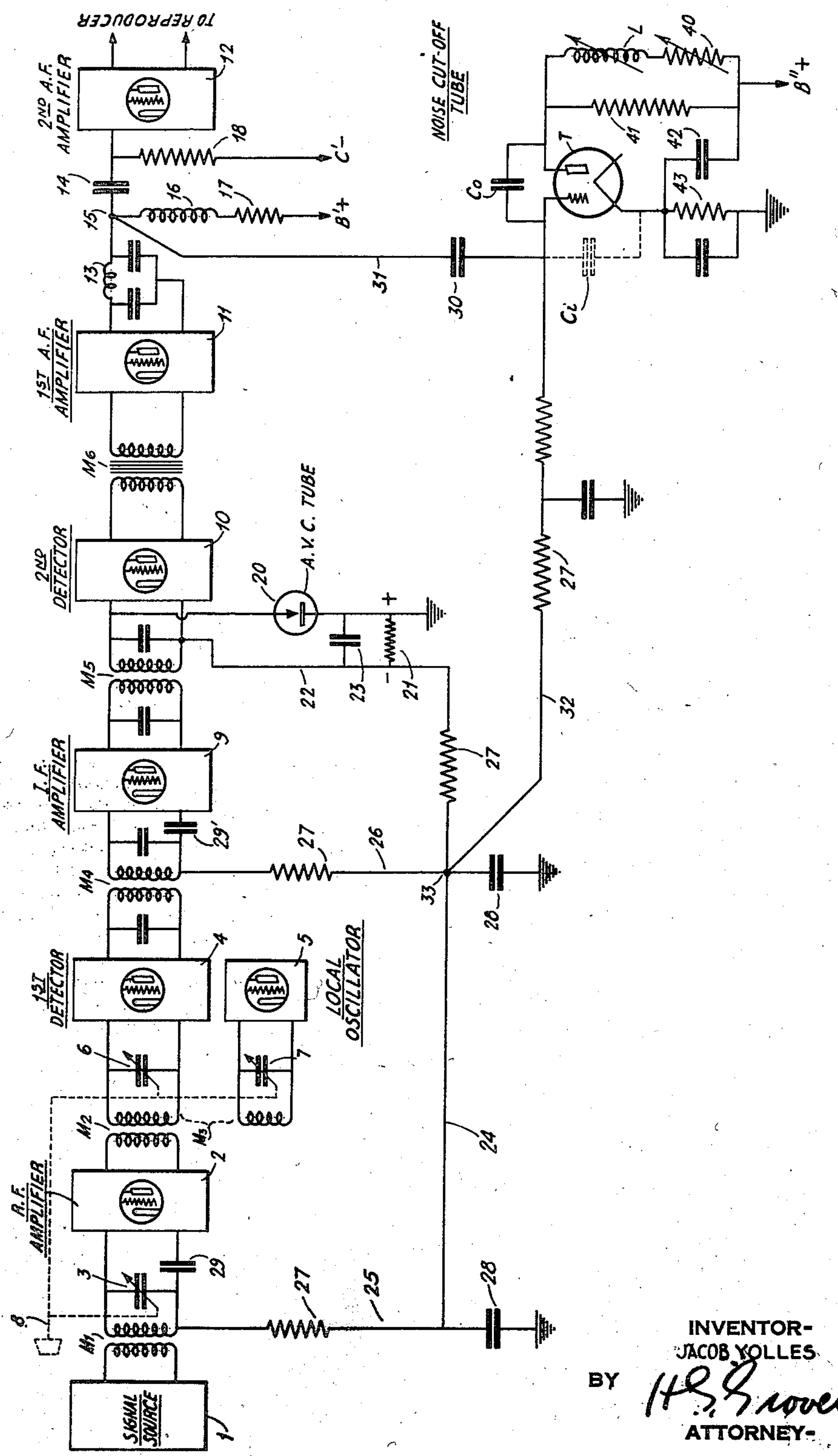

Fig. 4

INVENTOR-
JACOB YOLLES
BY H. G. Grover
ATTORNEY-

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ELECTRONIC TONE CONTROL

Jacob Yolles, Brooklyn, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application October 19, 1932, Serial No. 638,514

20 Claims. (Cl. 250—20)

My present invention relates to frequency discrimination networks, and more particularly to an improved electronic type of frequency discrimination device.

Frequency discrimination networks disposed in audio frequency transmission lines are well known. Such networks commonly include a manually operable adjusting device for controlling the audio frequencies to be discriminated against. For example, such a network, in a well known embodiment, consists in shunting across the audio frequency transmission line a condenser and adjustable resistor in series. In that case, variation of the resistor results in a variation in the intensity of the higher audio frequencies shunted across the line.

There exist many instances where it is extremely desirable to dispense with the use of an adjustable non-reactive impedance in a frequency discrimination network, and utilize instead an adjustable reactive element to control the audio frequency discrimination. This is particularly true in cases where it is desired to have the frequency discrimination network respond in an automatic fashion to a predetermined change occuring in the input to the audio frequency transmission line. For example, such an automatic frequency discrimination network is shown utilized as a noise suppressor arrangement in an automatic volume control receiver by W. S. Barden in U. S. Patent 1,947,822 of February 20, 1934, application Serial No. 530,268, filed April 15, 1931.

In the last mentioned application an electronic device is employed as an adjustable non-reactive impedance, the electronic impedance being connected to a reactance element. The conductivity of the electronic impedance is varied in accordance with predetermined variations of the signal carrier level input to a radio receiver. In this way, background noises are considerably minimized whenever the signal carrier level decreases to a value such that the amplification of the background noises dominates the amplification of the excessively decreased signal carrier energy.

Now, I have discovered a method of, and devised means for discriminating against the higher audio frequencies in an audio frequency transmission line by employing a variable reactance element, as for example a capacity, as the essential frequency discrimination element. Additionally, my present method is utilized in an automatic frequency discrimination network, and employs an electronic device as a variable capacity element in such a network.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide in an audio frequency transmission system, designed to transmit a wide range of audio frequencies, a frequency discrimination network consisting of a voltage operated condenser, and means for controlling the capacity of said condenser in such a manner as to alter the normal transmission frequency characteristic of the system to attenuate a predetermined portion of the range of audio frequencies.

Another important object of the present invention is to provide a tone control means in a radio receiver that will automatically, and without manual adjustment, alter the audio frequency response of the receiver in such a manner that on weak, or distant, stations, when signals are usually accompanied by noise, the high frequency response will be reduced thereby eliminating much of the noise without seriously impairing the quality of broadcast matter being received.

Still another important object of this invention is to provide a method of, and means for, reducing the reproduction of background noises in radio receivers equipped with automatic gain control arrangements, the method consisting in attenuating the relatively high audio frequencies with a voltage operated condenser device in accordance with variation in signal field strength whenever the ratio of received field strength to background noise level reaches a predetermined value.

Another object of the present invention is to provide in combination with an audio frequency amplifier, a tone control device which is capable of controlling the fidelity characteristic of the amplifier automatically and in such manner that the high audio frequency range is less responsive on weak or distant signals, the tone control device including a voltage operated reactance element adapted to variably by-pass the higher audio frequencies in accordance with signal field strength variation.

Still another object of the present invention is to provide in combination with a radio receiver comprising a radio frequency amplifier and a detector, an automatic volume control circuit adapted to vary the gain of said radio frequency amplifier in a predetermined manner, and additional means comprising a path to by-pass higher audio frequencies, the path including a tube whose effective input capacity is varied automatically in accordance with the functioning of said automatic volume control circuit, and additional means associated with the tube for adjusting the noise cut-off characteristic of the receiver.

Still other objects of the invention are to improve generally frequency discrimination networks adapted for use with audio-frequency transmission lines, and to particularly provide a voltage operated condenser, adjustable in operation, for use in conjunction with audio frequency amplifiers which is not only reliable in operation, but capable of a multiplicity of uses in connection with audio frequency systems.

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 drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings,

Fig. 1 shows diagrammatically a generalized audio frequency system embodying the invention,

Fig. 2 shows a generalized radio receiver, employing automatic volume control, utilizing the invention,

Fig. 3 graphically shows the operation of the receiver shown in Fig. 4,

Fig. 4 shows a superheterodyne receiver, employing an automatic volume control arrangement, and employing a modified form of the present invention.

Referring now to the accompanying drawings wherein like reference characters in the different figures represent similar circuit elements, attention is first directed to the generalized showing of an audio frequency transmission system, shown in Fig. 1, embodying the present invention. In this figure it will be observed that between a source of audio frequency energy and an audio frequency utilization means, there are connected a pair of conductors *c*. In shunt across the conductors there is connected a network including an electron discharge tube T, the network functioning as an audio frequency discrimination network.

The control electrode of the tube T is connected to the high potential conductor *c* while the cathode of the tube is connected to the low potential conductor through a path which includes a biasing resistor *r*, a source of variable grid potential (not shown), and the lead *t*. A by-pass condenser c_1 is shunted across the resistor *r* and the source of variable grid potential. The low potential side of the resistor *r* is connected to the anode of tube T through a path which includes the anode potential source B (not shown) and the load impedance Z.

Between the grid and anode of tube T there is provided a capacitance C_o, it being pointed out that this capacitance is not only to be considered as representing a condenser connected between the grid and plate of tube T, but also as including the inherent capacity existing between the grid and anode of tube T. The input condensive impedance of the tube T is represented by the symbol C_i, and is shown in dotted lines as connected between the lead *t* and the grid of the tube T.

The input condensive impedance of the tube T 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. By augmenting C_{gp}, as by employing external capacitance, and by using a suitable load Z, high values of capacity C_i may be reached. In other words, it will be seen that the symbol C_o represents the augmented resultant capacitance between the grid and plate of tube T, while the symbol Z designates the load in the plate circuit.

The magnitude of the input capacity of tube T may be controlled by varying G_m of the tube, as for example by altering the bias applied to the grid of the tube, or any other operating voltage. It can be shown that the value of the capacity C_i is approximately $(A+1)C_o$, where A equals the amplification of the tube produced by varying G_m. From this expression it will be seen that the network including the tube T 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 across the conductors *c*.

When the G_m of the tube is varied so as to increase the amplification, as by decreasing the negative bias applied to the grid of tube T, the electrical effect is equivalent to increasing the capacity C_i shunted across the conductors *c*. This variation of G_m is secured by properly adjusting the source of variable grid potential. It will therefore be seen that there has been provided an audio frequency discrimination network which essentially comprises a voltage operated condenser, and which specifically includes an electronic device whose admittance may be varied to adjust the frequency discrimination characteristic.

Considering Fig. 1, again, it will be readily seen that the source of audio frequency energy and the utilization means could very well be an audio frequency amplifier tube and a succeeding reproducer respectively, or two succeeding stages of audio frequency amplification respectively. In that case the network including the tube T could function as a path for variably shunting the higher audio frequencies, the shunting variation being controlled by the source of variable grid potential. The capacity C_o is shown as adjustable in order to point out clearly that the network may be readily employed between a tube and a reproducer, or between two tubes, or at any other point in an audio frequency transmission system, by initially adjusting the value of the resultant grid-plate capacity C_o to suit the requirements.

The source of variable grid potential, shown in Fig. 1, may comprise a source of potential which functions in accordance with the source of audio frequency energy, although it is understood that the variable source may be manually varied. Thus, in Fig. 2, there is diagrammatically shown a radio reception system, wherein the tube T and its associated circuits, is employed as a background noise suppressor device in conjunction with an automatic volume control system for the receiver. By applying the automatic volume control potential to the grid circuit of the tube T, 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 input capacity C_i of the tube T is a minimum. When the volume control potential is low, as in distant reception, the input capacity of the tube T is a maximum. Fig. 2 shows an application of such an automatic fidelity control device, or automatic tone control stage, to an audio frequency amplifier transformer. When weak signals are received, accompanied by background noises, the input capacity of tube T is connected across the audio transformer secondary S with a resulting attenuation of high tones and noise.

The receiver is conventionally shown, since it is only desired in this figure to show in a general way the application of the present invention to such an automatic tone control usage. The receiver may embody the usual pre-selector and radio frequency amplifier device, a succeeding detector and audio frequency amplifier tube T' whose input is coupled to the output of the detector by the audio frequency transformer M. The tone control, or noise suppressor, tube T has its grid connected to the grid of tube T' through a condenser K, while the grid of tube T is also arranged for connection to a source of automatic volume control potential by the lead t_1. The automatic volume control circuit and its connections to the radio frequency amplifier and the grid of tube T are not shown since the details of such a circuit are specifically shown in Fig. 4. It will be seen that the arrangement shown in Fig. 2 corresponds to the generalized showing of Fig. 1, the source of variable grid potential being applied between the grid and cathode of the tube T in this case, to vary the G_m of the tube thereby to vary the value of the shunt capacitance C_i which is electrically connected across the secondary S of the audio frequency transformer M. The condenser K is, of course, ineffective for alternating currents, the capacitance C_i being the sole control element; the series condenser K is obviously, in that case, many times larger than C_i.

In Fig. 4 there is shown in diagrammatic manner the essential features of a radio receiver embodying the utilization of the present invention shown in Fig. 2, as well as a noise cut-off adjustment device. The receiver shown in Fig. 4 represents in conventional manner a superheterodyne type of receiver which comprises the usual signal source 1, which may be an antenna, wire, or any other well known form of signal collection circuit. A radio frequency amplifier 2, having its input arranged for tuning by a variable condenser 3, is coupled to the output of the source 1 as at M_1. The output of the amplifier 2 is impressed upon the tunable input circuit of the first detector 4, as at M_2, the tunable input circuit of the detector including the variable tuning condenser 6, the input circuit of the detector also being coupled to a local oscillator 5 which includes a tuning condenser 7.

The symbol M_3 conventionally represents the fact that the local oscillator 5 is coupled to the detector 4 so as to impress upon the latter its locally generated oscillations. The tuning condensers 3, 6 and 7 are mechanically interconnected, as shown at 8, by any well known type of uni-control mechanism, it being clearly understood that the tuning condensers 3, 6, 7 and their respective resonant circuits are arranged so that regardless of the settings of the tuning condensers, there is produced in the output circuit of detector 4 a constant desired intermediate frequency. Such an arrangement is well known to those skilled in the art, and need not be described in any further detail than by referring to the arrangement shown by W. L. Carlson in U. S. Patent 1,740,331 of December 17, 1929.

The output circuit of the detector 4, the input and output circuits of the intermediate frequency amplifier 9, and the input circuit of the second detector 10 are all maintained fixedly tuned to the desired intermediate frequency which may be, for example, 175 kilocycles. The symbols M_4, M_5, designate respectively the couplings between the output of detector 4 and the input of amplifier 9, and the output of the latter and the input of the second detector 10. An audio frequency coupling M_6 couples the output of the second detector 10 to the input of the first audio frequency amplifier 11, while the output of the amplifier 11 is coupled to a second audio frequency amplifier through a path which includes the choke 13 in series with the blocking condenser 14.

The choke 13 is connected at its opposite terminals to audio frequency by-pass condensers. A point 15 intermediate the choke 13 and condenser 14 is shown arranged for connection to the positive terminal of the potential source B' for the anode of the amplifier 11. The connection includes the inductance 16 in series with the resistor 17, and the grid leak resistor 18 is connected to the negative terminal of the grid biasing potential source C' for the grid of the amplifier 12. The output of the amplifier 12 may be connected to any well known type of utilization means, such as a loud speaker reproducer.

The automatic volume control arrangement comprises the diode tube 20 whose anode is connected to the grid side of the input circuit of the second detector 10, and whose cathode is connected to the cathode side of the latter through a path which includes the control resistor 21 and the lead 22. It should be noted that a radio frequency by-pass condenser 23 is connected in shunt across the resistor 21 and that the positive side of the resistor 21 is grounded. The negative side of the resistor 21 is connected by leads 24 and 25 to the input circuit of the amplifier 2, and by the lead 26 to the input circuit of the intermediate frequency amplifier 9. Each of these leads includes a filter resistor 27, and the leads 25 and 26 are shown connected to ground through radio frequency by-pass condensers 28. Direct current blocking condensers 29 and 29' are respectively disposed in the cathode sides of the amplifier 2 and the amplifier 9 in order to block the flow of the volume control potential towards the cathodes of the amplifier tubes.

The noise cut-off tube T has its grid connected to the upper terminal 15 of the inductance 16 through a path which includes the coupling condenser 30 and the lead 31, it being further observed that a lead 32, including a filter resistor 27, connects the grid of the tube T to point 33 at the junction of leads 26 and 24. The cut-off tube T has its plate connected to the positive terminal of its plate potential source "B" through a path which includes an inductance L in series with a resistor 40, both the inductance L and the resistor 40 being adjustable, and both being shunted by a resistor 41. A by-pass condenser 42 is connected between the high potential side of the biasing resistor 43, its low potential side being grounded, and the anode lead arranged for connection to the positive terminal of the source "B". The input capacitance C_i is designated in dotted lines, and shown connected between the grid and cathode of tube T, while the augmented grid-plate capacitance of tube T is designated by the condenser C_o.

The operation of the system shown in Fig. 4 will now be explained, it being believed that the same will be clearly understood from the above description and the diagrammatic showing of Fig. 4. An increase in amplified signal energy delivered to the input of the detector 10, which increase is above a level corresponding to a desired reproducer volume output, results in an increased flow of current through the diode 20, and an increased potential drop across the resistor 21. This results in an increase in the negative control potential applied to the grids of the amplifiers 2 and 9, with the result that the gain of these two amplifiers is reduced to a value sufficient to decrease the intensity of the signal energy to the input of detector 10 to the desired reproducer volume level.

Similarly, when the signal energy delivered to the input of detector 10 falls below the aforementioned desired level, the potential drop across the resistor 21 decreases, with the result that the negative control potential applied to the grids of the amplifiers 2 and 9 decreases, and the gain of these two amplifiers therefore increases. This results in an increase in the signal energy intensity delivered to the detector 10, the increase being sufficient to bring the reproducer output volume to the desired operating level. In this way the tube 20 and its associated circuits automatically controls the volume level of the radio receiver.

Assuming, however, that the signal source delivers little, or no, signal carrier energy to the amplifier 2 because of the fact that the uni-control mechanism 8 is adjusted to a point between local station settings, or to a point corresponding to a weak distant station whose signals are usually accompanied by background noises, then the tube T and its associated circuits function as a means of tone control that will automatically, and without manual adjustment, alter the audio frequency response of the audio frequency amplifier in such a manner that the high audio frequency response will be reduced thereby eliminating much of the noise without seriously impairing the quality of the broadcast reception, particularly when weak or distant stations are being received. As pointed out heretofore the input capacitance C_1 is to be considered as electrically connected as a shunt condenser between the amplifiers 11 and 12. The condenser 30 exerts no control over the alternating current energy shunted through the path including C_1; the series condenser 30 is obviously many times larger than C_1.

This capacitance may be varied by varying the G_m of the tube T. The control potential for varying the G_m of the tube T is secured by virtue of the connection 32 between the grid of the tube T and the automatic volume control lead at point 33. It will now be seen that when little, or no, signal energy is being delivered to the input of detector 10, the potential drop across the resistor 21 greatly decreases, and the point 33 on the control potential lead 24 becomes relatively less negative, with the result that the potential on the lead of tube T becomes much less negative and the amplification of tube T increases. As pointed out heretofore this results in a maximum value of the capacity C_1, and a consequent maximum shunting of the higher audio frequencies between the point 15 and the ground.

The function of the path including the inductance 16 and resistor 17 is to provide the normal audio-frequency load for the tube 11, the inductance 16 being for correction of higher frequencies which tend to be shunted by the stray capacities of the system. It is usually possible to omit inductance 16. The function of the inductance L is to provide a suitable impedance as the load for the automatic control tube T. While a simple resistance load of a magnitude as would be used to get maximum gain, is satisfactory, the use of L gives the system a tunable feature and control of the cut-off fidelity curve.

The function of the resistor 40 is to control the effect of inductance L and prevent peaks due to parallel resonance of L with C_1. The resistor 40, in practice, is made up of the losses in the coil L by use of fine wire or other equivalent. The function of the resistor 41 is to provide the load for T. It is usually not required when L is employed, due to the losses in L.

In Fig. 3 the operation of the present invention is graphically demonstrated. The curves shown in Fig. 3 are secured by plotting frequency in cycles, as abscissa, against gain of the first audio amplifier stage as ordinates, it being pointed out that logarithmic abscissa is employed in plotting the curves. The dotted line curve A shows the operation of an audio frequency amplifier, as of the type represented by amplifiers 11 and 12 in Fig. 4, when no frequency discrimination network is employed. It will be seen that the gain of the first audio stage (the amplifier 11 in this case) is uniform over the entire audio frequency range up to 5000 cycles. For an arrangement of the type shown in Fig. 4, this will obviously not suffice, since background noises would be produced to an objectionable extent as soon as little or no signal energy was being received.

The curve B shows the operation of the audio frequency amplifier when employing a tone control network of the type including a condenser and resistor, usually in series, and wherein the resistor is varied to control the intensity of the shunting of the higher audio frequencies. The objection to this type of curve consists in considerable and undesirable attenuation of low and middle frequency tones, when the constants are chosen for adequate attenuation at higher frequencies. When middle and low tones are attenuated the volume level is lowered as well.

The full line curve C shows the noise cut-off characteristic of a receiver of the type shown in Fig. 4 when employing the present invention. It will be noted that there is no appreciable frequency discrimination up to 1,000 cycles, and that subsequent to the latter frequency cut-off occurs at a fairly rapid rate up to 5,000 cycles. The advantage of such a characteristic consists in preserving intelligibility with a minimum of background noise. Noise is evenly distributed over the frequency range and the greater the attenuation above 1,000 cycles, the less the noise. The intelligibility can be preserved by affecting the frequencies above 1,000 cycles, although a characteristic like B gives still greater noise elimination though at a loss of quality. When the automatic tone control is used for inter-carrier noise reduction, curve B is probably satisfactory.

The dotted lines D and E of the curve C show respectively the effect of the variation of the resistor 40, and the inductance L. These variations are produced by virtue of the following reasons: The intensity of the parallel resonance of C_1 and L is controlled by resistor 40. This controls the amplitude of the gain curve at the resonance frequency. The magnitude of L (and C_1) determine the position of the resonance peak. The peak varies with the bias of T.

These variations may be employed for the following functions: By controlling L, the position of cut-off frequency is controlled, to permit design variations for special purposes. By choice of value of resistor 40, curves B and C can be obtained, approaching B as resistor is increased.

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. For example: the use of my invention is not restricted to an automatic tone control arrangement, but it may be used for manual control, as for example with variations of grid bias.

What I claim is:

1. A method of suppressing background noises in a radio receiver which consists in collecting signal energy, amplifying such energy, detecting the amplified energy, varying the amplification of the collected energy to maintain the amplified signal energy for detection at a predetermined level during reception, and utilizing the detected energy to vary the capacity of an electronic capacitance in a sense to suppress the relatively high frequency components of the detected signal energy during such periods of reception when the signal field strength decreases below a predetermined value.

2. In combination, a radio frequency amplifier, a detector, means associated with the detector input for controlling the gain of the amplifier, and additional means including a voltage operated condenser responsive to the gain control means for automatically attenuating high audio frequencies in the detector output.

3. In combination, a radio frequency amplifier, a detector, means associated with the detector input for controlling the gain of the amplifier, and additional capacitative means, including a space discharge device, responsive to the gain control means for automatically attenuating high audio frequencies in the detector output.

4. In combination, a radio frequency amplifier, a detector, means associated with the detector input for controlling the gain of the amplifier, and additional means, including a variable voltage operated capacitance device having a low impedance to high audio frequencies, responsive to the gain control means for automatically attenuating high audio frequencies in the detector output.

5. In combination, a radio frequency amplifier, a detector, means associated with the detector input for controlling the gain of the amplifier, and additional means including a space discharge tube having a capacity between its grid and its anode circuit, responsive to the gain control means for automatically attenuating high audio frequencies in the detector output.

6. In combination, in a radio receiver, a radio frequency amplifier, means for converting the radio frequency signal energy into audio frequency signal energy, a control circuit for varying the gain of the radio frequency amplifier to maintain the signal energy at said means at a uniform level, and a voltage operated space discharge condenser circuit responsive to the gain control for attenuating predetermined audio frequencies.

7. In combination, a radio frequency amplifier stage including an electron discharge tube, a detector stage including a space discharge tube having its input electrodes coupled to the output electrodes of the amplifier tube, a gain control circuit including a space discharge tube having its input electrodes coupled to the input circuit of the detector tube, means connecting the grid circuit of said amplifier tube to the output circuit of said gain control tube, an attenuation circuit including a space discharge tube having its grid circuit connected to the output circuit of said gain control tube, and a condenser connected between the grid and plate of the attenuation tube.

8. A radio receiver including means for collecting signal energy, means for amplifying the collected energy, detection means for the amplified energy, means for controlling the amplification of the collected energy in accordance with received signal field strength to maintain a predetermined amplification level, and a potential operated capacitance for discriminating between predetermined frequencies of the detected signal energy in accordance with the received signal field strength.

9. A radio receiver including means for collecting signal energy, means for amplifying the collected energy, detection means for the amplified energy, means for controlling the amplification of the collected energy in accordance with received signal field strength to maintain a predetermined amplification level, and a voltage operated capacity for discriminating between the high and low frequencies of the detected signal energy in accordance with the received signal field strength.

10. A radio receiver including means for collecting signal energy, means for amplifying the collected energy, detection means for the amplified energy, means for controlling the amplification of the collected energy in accordance with received signal field strength to maintain a predetermined amplification level, and a voltage operated condenser for attenuating predetermined frequencies of the detected signal energy in accordance with the received signal field strength.

11. A radio receiver including a radio frequency amplifier, a detector, an automatic volume control circuit for regulating the gain of the amplifier in accordance with received signal field strength, and a potential operated capacitance for attenuating the high frequencies of the detected signal energy in accordance with the received signal field strength.

12. In combination in a radio receiver which includes a detector and an audio frequency amplifier network, means including a potential operated capacitance for attenuating the high audio frequencies of the detected signal energy.

13. A background noise suppressor for an automatic volume control system of a radio receiver, which receiver includes a high frequency amplifier, a detector, and means for maintaining the amplification of the high frequency energy at a predetermined level during reception, said suppressor comprising a potential operated capacitance, responsive to the operation of said amplification control means, for suppressing the relatively high frequency components of the detected signal energy during such periods of reception when the signal field strength decreases below a predetermined value.

14. In combination with a source of audio frequency energy and means for utilizing the energy, a device for regulating the frequency intensity of the energy transmitted between said source and means, said device including an electron discharge tube having the inherent capacity between its input electrodes connected in shunt across the source output, and means for varying the conductivity of said tube whereby the value of said

capacity is a function of the gain of the tube and varies over a predetermined range.

15. In combination, in an electrical wave transmission system, a source of electrical waves of plural frequency, a network for utilizing said waves, means coupling the source to the network, a direct current voltage operated capacitance connected to the coupling means, and adjustable direct current voltage means for adjusting the magnitude of said capacitance to transmit waves of at least one of the said frequencies through the capacitance.

16. A variable electronic condenser unit comprising an electron discharge tube having at least a cathode, grid and anode, the grid circuit of the tube comprising the condenser, reactive means common to the grid and anode circuits of the tube for providing a predetermined capacity in said condenser, inductive means in the anode circuit adapted to provide parallel resonance with said condenser at a predetermined frequency, and means for adjusting an electrical characteristic of the unit for producing desired changes in the value of said capacity.

17. An adjustable condenser unit comprising a tube having at least a cathode and two cold electrodes, the circuit between the cathode and one of the cold electrodes comprising the condenser, a capacitance common to both of said cold electrodes for producing a desired capacity value in the said condenser, inductive means in the circuit of the other cold electrode providing parallel resonance with said condenser at a desired frequency, and means for varying an electrical characteristic of the unit for changing the said value.

18. A variable condenser unit comprising a tube provided with a cathode, plate and control electrode, the circuit between the cathode and control electrode comprising the condenser, a condenser connected between the plate and control electrode to augment the capacity of said condenser, an inductor in the plate circuit resonating with said condenser at a predetermined frequency, and means for varying the space current flow in a predetermined manner for producing desired variations in the said capacity.

19. An adjustable voltage operated capacitance comprising a tube provided with a cathode and at least a grid and plate, the capacity between the grid and cathode comprising the said capacitance, auxiliary capacitance being provided between the grid and plate to augment the value of said first capacitance, an inductance in the plate circuit resonating with said first capacitance, and means for adjusting the space current flow of the tube in a predetermined manner for producing desired variations in the value of said first capacitance.

20. An adjustable voltage operated capacitance comprising a tube provided with a cathode and at least a grid and plate, the capacity between the grid and cathode comprising the said capacitance, auxiliary capacitance being provided between the grid and plate to augment the value of said first capacitance, adjustable inductive means in the plate circuit of the tube resonating with the first capacitance, and means for adjusting the space current flow of the tube in a predetermined manner for producing desired variations in the value of said first capacitance.

JACOB YOLLES.