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AUTOMATIC NOISE SUPPRESSION CIRCUITS

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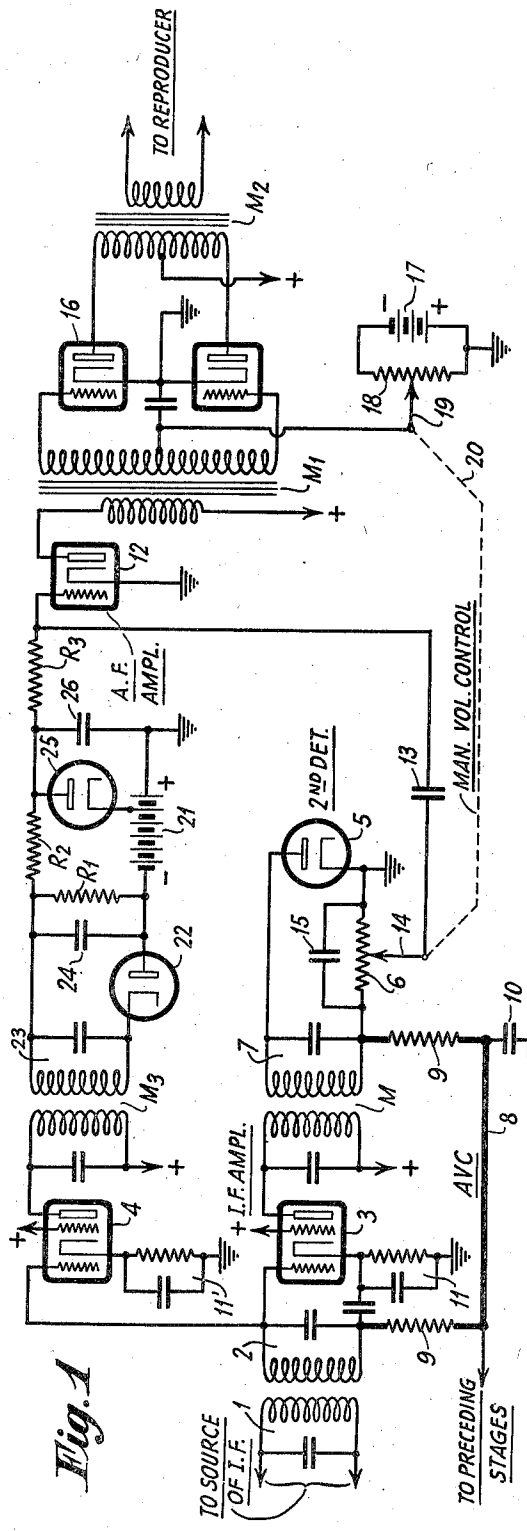


Fig. 1

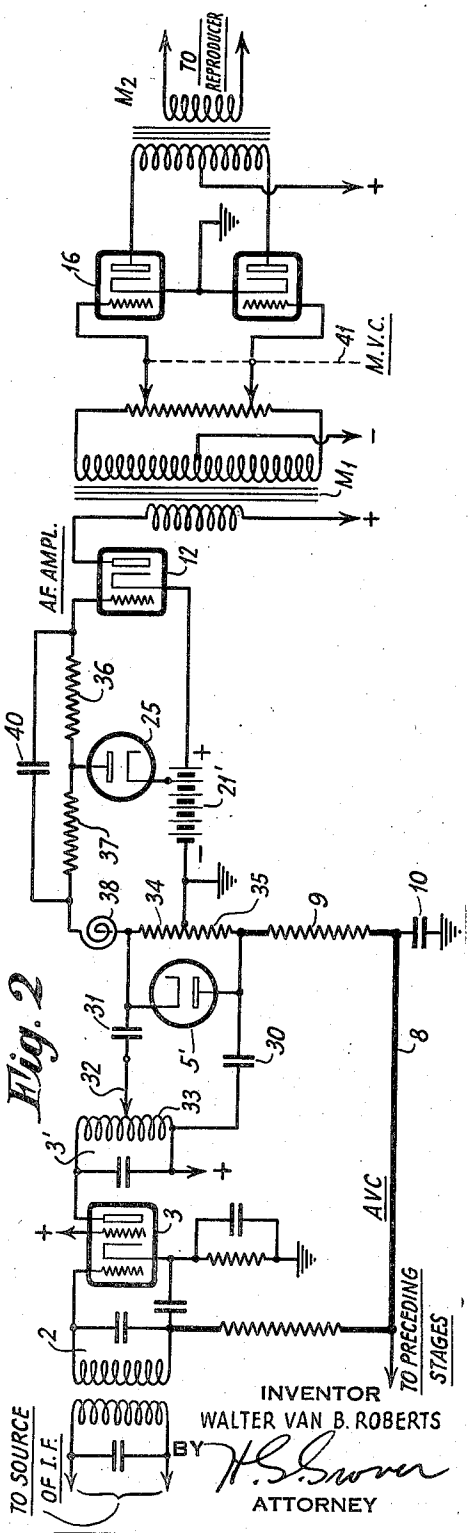


Fig. 2

INVENTOR
WALTER VAN B. ROBERTS
BY
ATTORNEY

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AUTOMATIC NOISE SUPPRESSION CIRCUITS

Walter van B. Roberts, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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9 Claims. (Cl. 250—20)

My present invention relates to automatic gain control circuits, and more particularly to automatic control circuits for suppressing background noise impulses in signal transmission systems.

Various types of automatic background noise suppression circuits have been disclosed in my application Serial No. 326,990, filed December 19, 1928, and in these circuits the transmission efficiency of the audio frequency amplifier network is automatically regulated in such a manner that the transmission efficiency is substantially impaired when the received signal amplitude decreases below a desired intensity value. Briefly, this is accomplished by maintaining at least one of the audio amplifiers at cut-off bias for signals below the desired amplitude, and utilizing a direct current voltage, dependent upon the received signal amplitude, for decreasing the cut-off bias when the signal amplitude increases above the desired amplitude.

In such types of noise suppression networks, if the automatic volume control circuit does not act to maintain substantially constant amplitude at the demodulator input over the entire range of useful signal strength, then there is a tendency for the cut-off bias on the audio amplifier to be reduced more in the presence of strong signals than in the case of the weak signals. Since the negative cut-off bias should only be reduced, when receiving desired signals, to an extent such that a normal operating negative bias remains for the audio amplifier, it will be seen that the compensating positive voltage may reduce the negative bias on the audio amplifier to an extent such that the audio amplifier grid will become positive and draw grid current, thereby introducing distortion.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a device, in an automatic background noise suppressor network of the type employing a positive voltage to overcome the effect of a noise cut-off audio amplifier bias, which functions to automatically reduce the magnitude of the positive voltage when the latter increases above a predetermined value.

Another important object of the invention is to provide in a radio receiver equipped with automatic volume control, a means for rendering the audio system inoperative by a cut-off biasing voltage whenever signals fall below a predetermined strength thereby to avoid the rather noisy condition that occurs when the amplification automatically becomes very high in the absence of sufficient signal strength to give a useful audio output; an additional voltage being supplied by a diode rectifier for reducing the aforesaid biasing voltage to a value suitable for normal amplification in the presence of signals of suitable intensity; and an auxiliary means being provided in electrical association with said diode rectifier for maintaining the effective bias of the audio amplifier at substantially a constant and suitable value over a wide range of signal intensity.

Another object of the invention is to provide a radio receiver of the type including a radio frequency amplifier and an audio frequency amplifier, a signal diode rectifier being provided to function simultaneously as a demodulator; a source of automatic volume control (AVC) voltage for the radio frequency amplifier; and a source of direct current voltage for rendering a normally inefficient audio amplifier fully operative in the presence of receivable signals.

Still another object of the invention may be stated to reside in the combination with a demodulator and audio frequency amplifier, of manually adjustable means for regulating the intensity of audio voltage fed to the audio amplifier and the type of audio amplification best suited for the audio voltage intensity; an automatic background noise suppression network being additionally provided for regulating the audio transmission efficiency in dependence on the received signal amplitude.

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 shows an embodiment of the invention wherein the quieting action is removed by a network entirely separate from the demodulator and AVC arrangement,

Fig. 2 shows a modification wherein a common diode is employed for producing AVC voltage; as a detector; and for producing the voltage required to bring the audio tube bias to the normal operating value.

Referring now to the accompanying drawing, wherein like reference characters in the different figures designate similar circuit elements, Fig. 1 shows that portion of a superheterodyne receiver which is necessary to an understanding of the invention. The numeral 1 designates a resonant

circuit tuned to the operating IF, and the circuit 1 may be disposed in the plate circuit of a preceding IF amplifier; or it may be arranged in the plate circuit of the first detector tube. Those skilled in the art will readily understand that the networks preceding circuit 1 may comprise the usual signal collector feeding into one or more stages of tunable radio frequency amplification. The first detector is also tunable, and is fed with locally produced oscillations from a local oscillator which is simultaneously tunable over the desired signal frequency range with the radio frequency amplifiers and the first detector. The signal range may be in the broadcast band of 500 to 1500 k. c.; and the operating IF may be chosen from a value of 75 to 465 k. c.

The circuit 1 is coupled to the IF tuned circuit 2, and the latter feeds a pair of IF amplifiers 3 and 4. The IF amplifier 3 is coupled through the transformer M to the second detector, or demodulator diode 5. The primary and secondary circuits of transformer M are each tuned to the operating IF, and the load resistor 6 is arranged in series between the grounded cathode of diode 5 and the low alternating potential side of the input circuit 7 of diode 5. The direct current voltage component of the rectified IF currents, flowing through resistor 6, is used for AVC of the preceding signal transmission tubes. Thus, the numeral 8 denotes the AVC lead from the anode side of resistor 6 to the grid circuits of the preceding tubes whose gains are to be controlled. The usual filter elements 9 and 10 are employed in the AVC lead to suppress the pulsating components in the AVC voltage. The networks 11 and 11′ denote the biasing means for amplifiers 3 and 4, and these provide the normal weak signal amplification bias for these amplifiers.

The audio component of rectified IF current flowing through resistor 6, is impressed upon the signal grid of the first AF amplifier tube 12. The signal grid of tube 12 is connected to any desired point on resistor 6 through a path which includes the audio coupling condenser 13 and the adjustable tap 14. The condenser 15 is arranged in shunt with resistor 6 for by-passing IF currents. The cathode of amplifier 12 is grounded, and the plate circuit thereof is coupled, through an audio transformer M_1, to the signal grids of the push-pull audio amplifier stage 16. The audio transformer M_2 couples the output of the push-pull stage 16 to any desired type of reproducer.

The normal operating bias for the push-pull stage 16 is derived from the direct current voltage source 17 which has a resistor 18 in shunt therewith. The cathodes of the tubes of stage 16 are grounded, and the positive side of source 17 is grounded. The signal grids of the push-pull arranged tubes are connected through a tap 19 to any desired point on resistor 18.

The numeral 20 denotes a manual volume control device which mechanically couples adjustable taps 14 and 19 so that a predetermined relation exists between the audio voltage transmission to amplifier 12 and the negative bias applied to the grids of the push-pull stage 16. Specifically, the manual volume control relates the movement of taps 14 and 19 so that when tap 14 is adjusted to provide a low level output, then the tap 19 is adjusted to a point on resistor 18 such that the bias on push-pull stage 16 is of a value which gives class A amplification with its well known freedom from distortion. On the other hand, for high level output adjustment of tap 14, the tap 19 is adjusted so that the bias on the push-pull stage is increased to make the stage act as a class B amplifier, thus permitting it to handle greater amounts of energy.

The action of the AVC is too well known to describe it in detailed fashion. Briefly, as the signal amplitude of received signals increases, the direct current voltage developed across resistor 6 increases, and therefore the negative bias applied to the controlled signal transmission tubes, such as tube 3, increases. This results in a decrease in gain of the signal transmission tubes with the result that the signal carrier amplitude at the input circuit 7 of demodulator 5 remains substantially constant. Since the gain of each of the controlled tubes is a maximum when weak signals are received, due to the absence of AVC bias of sufficient strength, such controlled tubes amplify noise impulses to a very great extent. A noisy condition occurs in the usual AVC receiver in the absence of sufficient signal strength to give a useful audio output.

Accordingly, a background noise suppression system is employed to overcome this noise effect. For signal amplitudes less than a predetermined value the amplifier 12 will be rendered substantially inoperative, and this is accomplished by connecting between the cathode and control grid of the tube a direct current voltage source 21. This source has its negative terminal connected to the control grid through a path which includes resistors R_1, R_2 and R_3.

The source 21 applies a negative bias to the control grid of tube 12 sufficient to prevent the tube from relaying audio currents impressed upon its grid through coupling condenser 13. When signals of a useful magnitude are turned in however, it is desired that this high biasing voltage be reduced to an extent sufficient to leave a bias on the grid of tube 12 enabling the tube to operate most efficiently. This is accomplished by providing a positive direct current voltage in polarity opposition to the direct current voltage from source 21, and the positive voltage varying in strength depending upon the received signal amplitude.

This variable positive voltage is provided by the IF channel which includes the amplifier 4. The diode 22 has connected between its anode and cathode a series path including resistor R_1 and the tuned secondary circuit 23 of the IF transformer M_3; the resistor R_1 being by-passed for intermediate frequencies by condenser 24. When the signals of desired magnitude are received, the current rectified by diode 22, and flowing through resistor R_1 produces a voltage drop sufficient to reduce the negative cut-off bias on amplifier 12 to a suitable value for efficient operation.

In other words, as long as the signal amplitude at circuit 23 is less than the amplitude at which a useful audio output is secured, whatever direct current voltage is developed across resistor R_1 is not sufficient to reduce the cut-off bias from source 21 to a point permitting efficient operation of tube 12. When the signal amplitude increases to the desired level, then the drop across resistor R_1 is sufficient to reduce the negative bias from source 21 so as to leave a residual desired operating negative bias on the grid of tube 12.

If the AVC action in the receiver is sufficiently powerful so that over the entire range of useful signal strengths the input to diode 22 is substantially constant, the bias on the grid of tube 12 will be sufficiently constant. It is to be noted

that the signal grid of amplifier 4 is under AVC regulation.

However, in the event that the AVC action is not very strong, there would be a tendency for the effective bias on tube 12 to be reduced more in the presence of strong signals than in the case of weak signals. It may even occur that the positive voltage across resistor R_1 counteracts the negative voltage from source 21 to such an extent that the grid of tube 12 becomes positive and causes distortion. To hold the effective bias on tube 12 more nearly constant there is provided the diode 25 whose anode is connected at the junction of resistors R_2 and R_3, and whose cathode is connected to a point of source 21 having a potential equal to the desired operating bias for tube 12. The resistor R_2 is traversed by current flowing through diode 25, it having been pointed out previously that this resistor is in the direct current path between the control grid and cathode of amplifier 12.

So long as the grid of tube 12 is more negative than it should be for efficient operation, no current flows through diode 25, but if the grid of the amplifier becomes less negative than it should be, current flows through diode 25 and produces across resistor R_2 a voltage drop which tends to make the grid of tube 12 more negative. In other words when diode 25 becomes conductive, a voltage is created across resistor R_2 which opposes the excess voltage developed across resistor R_1 by the relatively stronger signal. The result is that the bias on tube 12 will be of a satisfactory value over a wide range of signal strengths, while for extremely weak signals the bias rapidly becomes so great as to prevent the relaying of noise by tube 12.

Condenser 26 is connected between the positive side of source 21 and the anode of diode 25, and functions to prevent any audio voltage from rectification due to diode 22, from being developed across the diode 25. The resistor R_3 is provided to prevent the audio voltage impressed upon the grid of tube 12 from reaching diode 25.

The functions of diodes 22 and 5 may be combined in such a manner that a single diode performs the three functions of demodulation; AVC source; and suppression bias removal. In Fig. 2 such an arrangement is shown; and in this figure it will be observed that the diode 5' is coupled to the output of the IF amplifier 3 to receive IF energy therefrom. The anode of diode 5' is connected to the low alternating potential side of the output circuit 3' of the amplifier 3; the coupling being made through a condenser 30. The cathode of diode 5' is connected to any desired point on the coil of circuit 3' through a path which includes the condenser 31 and the adjustable tap 32. The tap 32 may be adjusted to a point on the coil 33 such that the impedances of the coupled circuits are satisfactorily matched.

Between the cathode and anode of diodge 5' is also connected a resistor, and a point thereon is grounded thereby providing the resistor portions 34 and 35. The audio amplifier 12 has its control grid connected to its cathode through a direct current path which includes in series the resistors 36 and 37, as well as IF choke coil 38, the resistor 34 and the negative direct current voltage source 21'. The audio-frequency by-pass condenser 40 is connected in shunt across resistors 36 and 37, and the diode 25 is connected between the junction of resistors 36 and 37, and a predetermined point on source 21'.

In the arrangement of Fig. 2 the intermediate frequency voltage is impressed upon the diode 5' which has across it the resistor 34—35 as a load resistance. The junction of resistors 34 and 35 is maintained at a fixed direct current potential so that the lower end of resistor 35 develops a negative potential which is used for AVC. The cathode side of resistor 34 develops a positive potential with a superposed audio frequency variation. This audio variation is fed to the grid of audio tube 12 through the path including the choke 38 and the large capacity 40.

The direct current component of the potential across resistor 34 is fed to the grid of tube 12 through the path including choke coil 38 and resistors 37 and 36. The cathode of tube 12 is maintained positive by the source 21', and the latter has sufficient voltage to cut off the flow of plate current through tube 12 in the absence of sufficient voltage developed across resistor 34 to reduce the cut-off bias to the desired extent. The diode 25 functions in the manner described in connection with Fig. 1. It cooperates with resistor 37 to provide a compensating negative direct current voltage for the grid of tube 12 whenever the drop across resistor 34 is sufficiently great to render diode 25 conductive. Resistor 36 functions in a manner similar to resistor R_3 in Fig. 1, while choke coil 38 prevents IF voltage from being impressed anywhere except across diode 5'.

It will therefore be seen that in Fig. 2 the diode 5' and its associated circuit performs the three functions noted heretofore, and that the additional diode 25 acts to maintain the bias on audio tube 12 substantially constant regardless of whether relatively strong signals are received, or whether weak stations are being tuned in. Instead of employing separate diodes 5' and 25, a tube of the 6H6 type may be employed, such a tube being provided with independent cathodes and anodes and thereby furnishing independent diode rectifiers. Furthermore, in Fig. 2 there is shown a manual volume control device 41 which may be employed in place of the manual volume control 20 of Fig. 1. It will be observed that the control device 41 acts to vary the intensity of the audio voltage applied to the grids of the push-pull stage 16.

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 is claimed is:

1. In combination with a source of signal waves and an audio frequency amplifier, a diode rectifier including a resistor in its space current path, means coupling the source and diode whereby said diode rectifies impressed waves and produces a voltage drop across the resistor which varies in accordance with signal strength, means for producing a predetermined negative bias for said audio amplifier, means for establishing the negative end of said resistor at a fixed potential, and means connecting the positive end of said resistor to the input electrodes of said audio amplifier whereby the varying positive potential at the positive end of the resistor is utilized in opposition to said negative bias of the audio amplifier and additional means, responsive to an increase in said positive potential above a desired value, for biasing said amplifier in a negative sense.

2. In combination with an audio amplifier including means for maintaining the amplifier normally cut off, a source of signal waves, a diode rectifier coupled to said source and including a resistor in circuit therewith whereby rectified signal currents flow through the resistor, means for establishing a point of said resistor at a fixed potential, and means for connecting the input grid of said audio amplifier to a point on said resistor which is positive with respect to the fixed potential point, whereby said cut-off bias is opposed by the positive potential of said positive point, and additional means, responsive to an increase in said positive potential above a desired value, for biasing said amplifier in a negative sense.

3. In a system as defined in claim 2, additional means for impressing the audio frequency component of said rectified currents upon the input grid of said audio amplifier.

4. In a superheterodyne receiver of the type including a source of intermediate frequency energy, a diode rectifier and an audio amplifier, a fixed source of bias for said audio amplifier sufficient to cut off its action entirely, means in circuit with said diode for developing a voltage to reduce the effective bias on said audio amplifier to a suitable value for efficient operation, and additional means in electrical circuit with said rectifier and audio amplifier input electrodes and responsive to an excessive increase in said reducing voltage for preventing said effective bias from being reduced appreciably below said suitable value in the presence of strong signals.

5. In a superheterodyne receiver having a negatively biased audio frequency amplifier tube, a unidirectional conductor connected between a point having the same potential as the grid of said tube and a point having a potential whose value is a suitable grid potential for efficient operation of said tube, said unidirectional conductor being so poled as to permit passage of current only when the negative potential difference between the amplifier grid and cathode is less than said suitable value, and a resistance arranged to be traversed by said current to produce a voltage drop in said grid circuit tending to prevent the effective negative bias from falling appreciably below said suitable value.

6. In combination with a source of signals and an audio amplifier, a diode rectifier having a resistance load circuit, an intermediate point of said load being maintained at a constant potential so that the relative potential becomes positive at one end, and the other end becomes negative when signals are impressed from the source upon the diode circuit, said amplifier having its cathode connected to said intermediate point, an automatic volume control circuit connected to the said negative potential end, means for applying a bias to the audio amplifier which is sufficiently high to render the same inefficient, and means for applying the potential at the positive end of said load to the audio amplifier to neutralize the aforesaid bias.

7. In combination with a source of signals and an audio amplifier, a diode rectifier having a resistance load circuit, an intermediate point of said load being maintained at a constant potential so that the relative potential becomes positive at one end, and the other end becomes negative when signals are impressed from the source upon the diode circuit, an automatic volume control circuit connected to the said negative potential end, and means for impressing the audio frequency voltage at the positive end of said load upon said audio frequency amplifier, means for applying a bias to the audio amplifier which is sufficiently high to render the same inefficient, means for applying the direct current potential at the positive end of said load to the audio amplifier to neutralize said bias, and additional means for preventing said bias from being reduced appreciably below a predetermined operating value in the presence of relatively strong signals.

8. In combination with an audio amplifier including means for maintaining the amplifier normally cut off, a source of signal waves, a diode rectifier coupled to said source and including a resistor in circuit therewith whereby rectified signal currents flow through the resistor, means for establishing a point of said resistor at a fixed potential, means for connecting the input grid of said audio amplifier to a point on said resistor which is positive with respect to the fixed potential point, whereby said cut-off bias is opposed by the positive potential of said positive point, a second diode, means for normally rendering the second diode non-conductive, a second resistor in series with said first resistor in the space current path of the second diode, whereby the second diode becomes conductive when the direct current voltage drop across said first resistor exceeds the cut-off bias on the second diode, and means for impressing the negative bias produced across the second resistor on the signal grid of said audio amplifier.

9. In combination with a signal transmission tube whose input electrodes are coupled to a source of signals, means establishing the gain of said tube at an abnormally low value in the absence of signals above a desired intensity, means responsive to an increase in signal intensity above the desired intensity for opposing the effect of said first means and restoring said gain to a normal value, and auxiliary means, responsive to the action of said opposing means, for reducing the tube gain when said opposing means increases said gain abnormally.

WALTER VAN B. ROBERTS.