

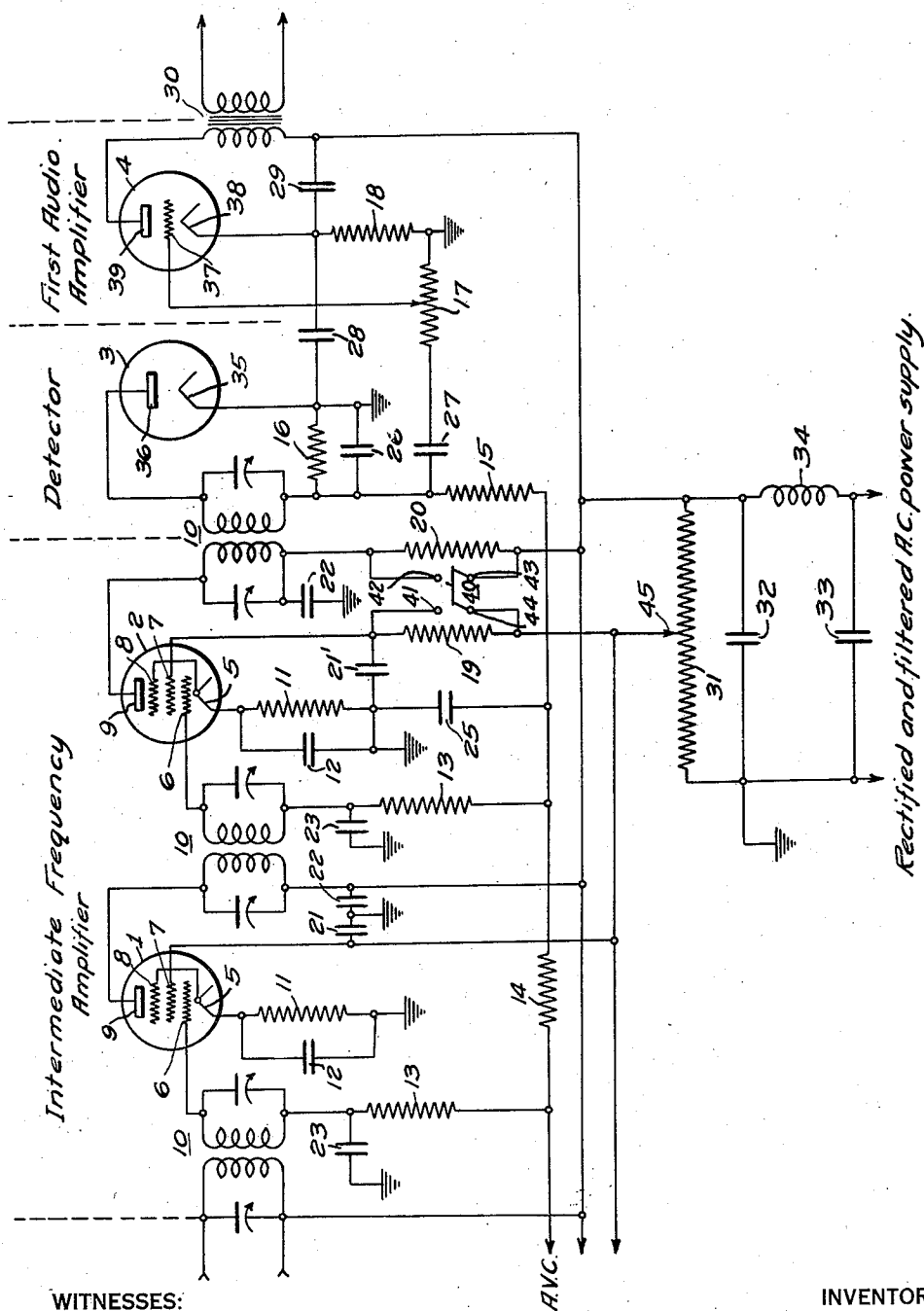
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NOISE SUPPRESSION CIRCUITS

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WITNESSES:

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NOISE SUPPRESSION CIRCUITS

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This invention relates to radio receiving systems, and more particularly to receivers of the type wherein the sensitivity of the amplifier stages is automatically varied in inverse proportion with the strength of the received carrier wave.

An objectionable feature of radio receivers equipped with automatic volume control resides in the noise appearing in the loud speaker when the set is tuned from one station to another. This noise is especially strong between stations where no carrier wave is present, which would actuate the automatic volume control and thereby reduce the sensitivity of the receiver. The interfering noise is attributed to the fact that in receivers of the above type the amplifying tubes at no signal input are operated to the full extent of their amplifying power, and in this state of maximum sensitivity will amplify minute electrical disturbances as well as even slight variations of current appearing within the tube. The latter condition is usually referred to as the "shot-effect," and results in a steady high-frequency hiss in the tube output due to the fact that the electron emission from the cathode is not perfectly regular but spasmodic in character.

From the foregoing, it is readily seen that upon the absence of the carrier wave to which the receiver is tuned the automatically readjusted sensitivity of the set results in objectionable inter-channel or back-ground noises. This may be experienced not only in the tuning of the receiver but also when atmospheric conditions cause fading of the signal.

In order to eliminate the above disadvantage, various circuits have been designed in which auxiliary devices performed the silencing function. Some were in the form of manually operated switches, so-called "muteing" buttons which were pressed down at the time the tuning dial was moved and thereby short-circuited certain portions of the signal amplifying channel. Others employed auxiliary vacuum tubes performing a trigger function in the audio amplifier circuit. The auxiliary tube was subjected to the automatic volume control potential in such manner that upon the absence of a control potential, the heavy current drawn by the tube disbalanced a fixed state of voltage distribution necessary for the operation of the tubes in the audio amplifying system. The latter type, known as the quench or QAVC system, while automatic in operation requires the use of an extra tube in the receiver which contributes nothing to the primary

function of the vacuum tubes in the set. Furthermore, it complicates the circuit inasmuch as several components to the receiver proper must be added in order to obtain an operative arrangement.

The primary object of this invention is to eliminate inter-channel or back-ground noises in a radio receiver, by providing a circuit arrangement which requires no additional tubes nor auxiliary devices to perform the stated objective.

It is a particular feature of this invention that, the means provided for suppressing inter-channel noise, is simple in operation and easily applicable to all types of radio receivers having automatic sensitivity controls.

A further advantage resulting from the use of the proposed means in accordance with this invention is that existing receivers may easily be modified to perform in the manner stated without requiring any major changes or adjustments in the receiver circuit.

Additional objects and advantages will be apparent from the following description of the invention, defined in particularity by the appended claims and taken in connection with the accompanying drawing, in which the invention is illustrated diagrammatically in the intermediate frequency amplifier portion of a radio receiver.

Referring to the drawing, the single figure shows a portion of a radio receiver, namely, the signal translating channel of the intermediate frequency amplifier in a superheterodyne type receiver; the detector stage and the succeeding audio frequency stage. The other parts of the circuit preceding the intermediate frequency amplifier have been omitted for the sake of simplicity, inasmuch as the invention herein described may advantageously be employed to one high-frequency amplifying stage. It is assumed, of course, and anybody skilled in the art will readily recognize, that an oscillator and first detector stage will precede the arrangement shown in the drawing to complete a superheterodyne receiver, and an additional stage of audio frequency amplification may also be needed if a loud speaker is to be operated. Furthermore, it will be clear as the description explains the invention in its technical details, that it need not be restricted to a superheterodyne type of receiver but will operate in any radio frequency stage as long as there is an automatic control responding to the strength of the carrier wave.

The circuit shown essentially consists of two high-frequency amplifying stages including the vacuum tubes 1 and 2, a detector stage including

the detector tube 3 and an output stage including the first audio amplifier tube 4. The high-frequency amplifying tubes are of the pentode type, having an anode 9, a cathode 5, a control grid 6, a screen grid 7 and suppressor grid 8. The latter in some tubes is tied to the cathode within the tube and in others, the connection may be effected outside of the tube proper. The input circuit to each pentode tube comprises a transformer 10 of the double-tuned type, generally employed in intermediate frequency, or commonly referred to as IF stages. In series with each cathode 5 is a resistor 11 which is so proportioned as to effect the necessary voltage drop by the anode current of the tube for the minimum operating bias required in accordance with the type of tube used. Each resistor 11 is by-passed by a condenser 12. Following the input circuit of each stage, the return of the secondary coil of each transformer 10 connects through resistors 13 and 15 to the load resistance 16 of the detector tube 3 and thence to the cathode 35 thereof which is connected to ground. An additional resistor 14 for filtering purposes is included in this circuit and by-pass condensers 23, 25 and 26 provide low impedance paths to ground for high-frequency currents.

The circuit above referred to comprises the automatic volume control portion of the receiver together with the detector tube 3 which is the source of automatic volume control, or using its accepted abbreviated form, A. V. C. voltage. The detector tube 3 operates as a diode and rectifies the high-frequency current in the secondary winding of the transformer 10 connected between its anode 36 and cathode 35 in series with the load resistance 16 previously referred to. Due to the rectification of the tube 3, a voltage drop is effected by the current flowing in the resistor 16 which can be resolved into two components: one the modulated component of the high-frequency current which is transmitted through the coupling condenser 27 to the grid resistor 17 of the audio amplifier 4 and comprises the audio frequency; and a unidirectional component which at the point where the resistors 15, 16 and the secondary winding of the transformer 10 join is negative with respect to the cathode 35 and proportional in magnitude to the high-frequency voltage supplied by the amplifying tubes to the detector tube 3. Therefore, when there is no current flow in the resistor 16, the grids 6 are effectively at ground potential and biased only by the minimum bias derived from the resistors 11. This is the case when there is no signal voltage to the detector tube. However, when the detector tube is supplied with signal voltage and rectifies the latter, the grids 6 will be biased increasingly negative by the rectified component of the signal voltage appearing across the resistor 16. This is essentially the A. V. C. action and will be further exemplified in describing the operation of the circuit as a whole.

The output circuit of each amplifier tube includes the anodes 9 and the primary winding of its corresponding transformer 10. Condensers 22 by-pass the output circuit to ground. The first IF amplifier tube plate return is connected directly to the power supply schematically shown by filter condensers 32, 33, filter reactor 34 and the voltage divider 31. The second IF tube plate return includes a series resistance 20 which may be short-circuited by contacts 42 and 43 of the switch 40. The screen grid 7 of the tube 1 by-passed by condenser 21 returns directly to the

tap 45 of the voltage divider 31, whereas the screen grid 7 of the tube 2, by-passed by condenser 21' includes a series resistance 19 in the return lead to the tap 45, and may be short-circuited by contacts 41 and 44 of the switch 40. The two resistors 19 and 20 form an important part in the operation of the system to silence the receiver upon absence of signal voltage, and more will be said thereof later.

The first audio amplifier tube 4 is connected in a conventional manner, having a bias resistor 18 connecting the cathode 38 to ground and the plate circuit includes a suitable output impedance shown by an audio transformer 30. The arrows of the secondary winding indicate that the output circuit may terminate in a succeeding amplifier or a suitable translating device not shown here. Similarly the arrows affixed to the A. V. C. potential supply lead, the screen and plate supply conductors, indicate that preceding portions of the receiver may be supplied from the same source for all operating potentials. The filaments for heating the cathodes of the various tubes and the source of heater current have been omitted in order to simplify the drawing. It is well known in the art that the heaters may be supplied from any suitable alternating current source, such as a transformer, for instance.

Before describing the operation of the receiving system embodying the improvements in accordance with this invention, a clearer understanding thereof will be had by defining the term "normal order of potential" which is to signify here the proportion of the voltages supplied to a vacuum tube in order that it may function in the manner intended, for example as an amplifier. In other words, by normal order is meant the respective magnitudes of operating voltages required for a particular tube for its principal electrodes. In a screen grid tube, for example, to operate as an amplifier the normal order of potentials is a higher positive potential on the anode than on the screen, both potentials being taken with respect to the cathode. Now, let the vacuum tube 2 be considered first in connection with its associated components but apart from the rest of the system. The circuit elements are so proportioned that with the minimum grid bias potential derived from resistor 11 by the plate current flow, the operating potentials on the screen 7 and anode 9 will be sufficiently lowered due to the voltage drop in the series resistors 19 and 20 and in such proportion as to upset the normal order of potential, the screen becoming more positive with respect to the cathode than the anode. This causes blocking of the tube for signal transmission. Stated in another way, with maximum sensitivity setting of the tube, the plate current causes a voltage drop of such magnitude across the resistor 20, and similarly, the screen current across the resistor 10, that the effective plate potential falls below that of the effective screen grid potential and consequently the mutual conductance of the tube falls nearly to zero. However, as soon as an increase of negative bias is applied to the grid 6, the plate current decreases, which, in turn, decreases the currents in both resistors 19 and 20. Thus, a negative increase in grid bias of the tube 2 causes the average plate voltage to rise producing thereby an increased mutual conductance with consequent increase of amplification. Considering the first I. F. amplifier tube, which is conventionally connected and includes no means affecting its operating potentials, the

mutual conductance increases with decrease of bias potential and at no signal input to the system, as for instance, when the set is tuned between adjacent broadcast channels, the amplification is at maximum. Whereas, in the presence of the signal with increased grid bias, its amplification decreases until equilibrium is reached between signal transfer and control potential.

Bearing in mind the differential function of the first and second amplifier tubes, it will be seen that in the presence of a carrier wave and due to the A. V. C. action, both tubes become operative and normal reception is obtained. On the other hand, in the absence of a carrier wave while the first amplifier tube is at maximum gain the second amplifier tube is inoperative and no signal in the form of interfering noises and hiss is transferred past the stage preceding the detector.

The circuit constants and the resistance values for resistors 16 and 20 are so proportioned that while there is no transfer to the detector tube of the amplified electrical disturbances through the tube 2, the signal voltage of a broadcasting station considered local to the receiver, having a carrier intensity greatly in excess of the amplified value of the above disturbances, will pass through by capacity effect and in sufficient magnitude to be acted upon by the detector. The resultant A. V. C. bias offsets the inoperative state of the tube 2 and normal reception is obtained.

The simple switch 40 is included for the purpose that, if full sensitivity of operation is desired at all times as for instance when extremely weak signals are to be tuned in, the resistors 19 and 29 be short circuited.

It has also been observed in practice that in some receivers it is advantageous to include the noise suppression feature in more than one stage.

From the above description, it will be apparent that the only change necessary to a standard receiver embodying automatic volume control in order to obtain the advantages of the invention, constitutes the mere addition of a resistor in the screen grid and plate lead of the amplifier to the voltage supply source, so proportioned that under conditions which would normally produce maximum amplification in this stage, the plate and screen voltages drop to a relatively low value, and with the plate voltage at a lower value than the screen voltage, the tube becomes inoperative as an amplifier. Through the addition of these two elements to an otherwise standard circuit, the objects of this invention have been attained and such results obtained which in accordance with present practice necessitates the addition of another electron discharge device to the circuit, together with such circuit elements which are normally required to enable an electron discharge device to function in its intended manner.

While the invention has been described in great detail, it is apparent that it is susceptible to minor variations without departing from the scope of the invention embodied therein, and it is not to be limited in protection to the details shown, except as may be required by the prior art and the appended claims.

I claim as my invention:

1. In combination, means for amplifying high-frequency energy comprising an electron discharge device having a cathode and a plurality of principal electrodes, means for applying a normal order of potential to said principal electrodes

with respect to said cathode during periods of signal amplification, means responsive to variations in the intensity of the incoming signal wave for maintaining the volume level of said amplifier substantially constant during amplification of signals, and means for reversing the normal order of potentials to certain of said principal electrodes to render said amplifier substantially non-operative during no signal periods.

2. In combination, means for amplifying high-frequency energy comprising an electron discharge device having a cathode and a plurality of principal electrodes, means for applying a normal order of potentials to said principal electrodes with respect to said cathode during periods of signal amplification, means responsive to variations of the incoming carrier wave for varying the amplification of said amplifier in accordance with said variations in carrier intensity, and means for reversing the normal order of potentials to certain of said principal electrodes to render said amplifier substantially non-operative during the absence of an incoming carrier wave.

3. In combination, an electron discharge device having a cathode, an anode and an intermediate electrode, means for applying positive potentials to said anode and intermediate electrode, the potential on said anode being of a higher order than that on said intermediate electrode during signal amplification periods, and means for dropping the voltage to said anode to a value less than that applied to said intermediate electrode during no signal periods.

4. In combination, an amplifier including an electron discharge device having a cathode, an anode and an intermediate electrode, means for applying positive potentials to said anode and intermediate electrode, the potential on said anode being of a higher order than that on said intermediate electrode during amplification periods, means for maintaining the volume level of said amplifier substantially constant during amplification of signals, and means for reducing the voltage of said anode to a value below that applied to said intermediate electrode during no signal periods.

5. In combination, an electron discharge device having a cathode, an anode and an intermediate electrode, means for applying positive potentials to said anode and intermediate electrode, the potential of said anode being of a higher order than that of said intermediate electrode during amplification of signals, a voltage dropping device in circuit with said anode and having a value of impedance sufficient to drop said anode potential below that of said intermediate electrode potential when said amplifier is otherwise adjusted for maximum amplification.

6. In combination, an electron discharge device having a cathode and principal electrodes, means for applying a normal order of potential to said principal electrodes with respect to said cathode essential to the operation of said device during periods of said signal amplification, means for applying a biasing potential to said amplifier to reduce the amplification factor of said amplifier from a predetermined maximum value and means operative upon loss of said bias for reversing said normal order of application of potentials to said principal electrodes causing inoperativeness of said device.

7. In combination, an electron discharge device having a cathode, an anode and an intermediate electrode, means for applying positive potentials

to said anode and intermediate electrode, the potential on said anode being of a lower order than that on said intermediate electrode during the absence of signal energy in the input circuit of said amplifier, and means responsive to the application of signal energy to the input circuit of said amplifier for causing said anode potential to rise in value above that of said intermediate electrode potential.

8. In a signalling system, a signal-translating channel including amplifiers producing an amplified signal output, means responsive to said amplified signal output for producing a unidirectional voltage, means for controlling the amplification in certain of said signal amplifiers in inverse proportion with said unidirectional voltage, and means for applying said unidirectional voltage to a control element of one of said amplifiers to control the responsiveness thereof in direct proportion therewith, whereby said signal amplifier is rendered inoperative when the signal input applied to the other of said amplifiers decreases below a certain value.

9. In a signalling system, a signal transmission channel including an output coupling element, a pentode amplifier coupling said output to a rectifier producing a rectified signal voltage, said pentode amplifier having in its plate lead a high resistance which reduces its average plate voltage to a point of inoperativeness, means for rendering said pentode amplifier operative upon signal transmission of a predetermined intensity by making its control grid more negative in accordance with said rectified voltage and thereby increasing its plate voltage.

10. In a signalling system, a pentode amplifier, a rectifier for producing a unidirectional voltage dependent on the amplification in said pentode amplifier, a connection from a point in said rectifier circuit to a control element of said pentode amplifier for automatically adjusting the control grid bias, a high resistance in the plate lead of

said pentode amplifier proportioned to cause said amplification to increase in predetermined relation to increase of control grid bias, whereby in response to a variation of input to said signal amplifier said unidirectional voltage is caused to vary with respect to said control grid bias substantially in accordance with said predetermined relation.

11. In a signalling system, a signal channel producing a signal output, a pentode amplifier coupling said output to a circuit including a rectifier for producing a unidirectional voltage dependent on said output and on the amplification in said pentode amplifier, a connection from a point in said rectifier circuit to a control element of said amplifier for controlling said output in response to said unidirectional voltage, a high resistance in the plate lead of said pentode amplifier proportioned to cause said amplification to increase in predetermined relation to increase of control grid bias, and means for preventing said amplifier from responding until the output from said rectifier exceeds a predetermined value, whereby in response to a variation of input to said signal amplifier said unidirectional voltage is caused to vary with respect to said control grid bias substantially in accordance with said predetermined relation.

12. In a signalling system, a signal amplifier producing an amplified signal output, a pentode amplifier coupling said output to a rectifier producing a rectified signal voltage, said pentode amplifier having in its plate lead a high resistance which reduces its average plate voltage to a point of inoperativeness, means for reducing the amplification in said signal amplifier in accordance with said rectified voltage and simultaneously rendering said pentode amplifier operative, by making its control grid more negative and thereby increasing its plate voltage, in accordance with said rectified voltage.

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