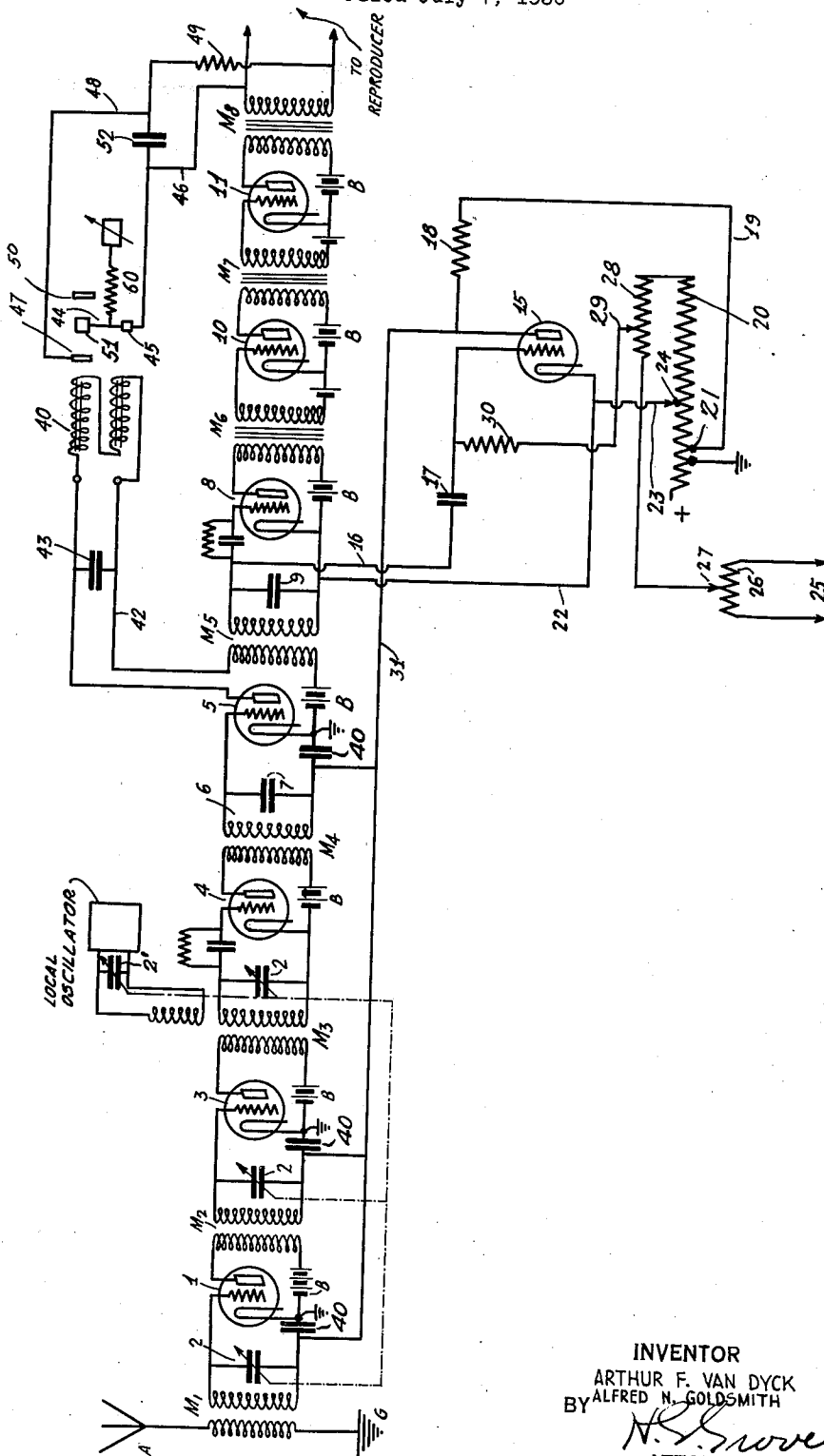


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AUTOMATIC VOLUME CONTROL

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AUTOMATIC VOLUME CONTROL

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The present invention relates to radio receiver reproduction control, and more particularly to improvements in automatic volume control of receivers.

It has become a common expedient to equip a radio broadcast receiver with an automatic gain, or volume, control arrangement in order to maintain the reproducer volume at approximately constant value with signal intensity levels which vary over a considerable range. While actual experience with such arrangements reveals fair operation and effectiveness of automatic volume control, yet an operating disadvantage is often encountered.

When a receiver of this type is being tuned over its tuning frequency range, at all tuning positions where no carrier is present the noise from static and other interference sources becomes highly undesirable. In fact, such increase in background noise level is effective in disturbing the nicety and comfort of operation of the receiver. This increase in background noise level is directly attributable to an inherent characteristic of the automatic volume control arrangement, since, in the absence of carrier, the automatic volume control increases the sensitivity of the receiver to maximum, and therefore the response to background noises, and reproduction thereof, is at a maximum.

Now, we have discovered a method of, and devised means for, eliminating the increase in background noise level when a receiver, embodying an automatic volume control arrangement, is tuned through a point in its frequency range where no carrier is present, the method basically involving rendering the signal translating means inefficient at such points.

Accordingly, it is one of the main objects of our present invention to provide a method of, and means for, operating a radio receiver provided with an automatic gain control so that the reproduction of undesirable noises is substantially eliminated during the tuning operation, the reproduction function of the receiver being rendered highly inefficient at such points during tuning where the background noise level tends to increase.

Another important object of the invention is to provide an improved type of automatic volume control for receivers comprising means for impairing the operation of the receiver whenever the receiver is tuned through a point where no carrier is present, or where the carrier intensity becomes too weak to be useful, the said means including a device responsive to a pre-

termined decrease in carrier intensity to render the receiver audio arrangement inoperative or inefficient.

Another object of the invention is to provide in a receiver equipped with an automatic volume control, an arrangement including means responsive to a predetermined carrier intensity level decrease, and additional means, associated with the responsive means, for rendering the receiver reproducer inoperative or inefficient during said decrease.

Still another object of the invention is to provide in a radio receiver including tuning means, additional means, operative during the tuning process, to maintain the background noise level below a predetermined value.

And still another object of the invention is to provide in a radio receiver including a signal translating means, additional means for automatically rendering the translating means inefficient whenever the intensity level of the carrier to which the receiver is tuned decreases below a predetermined value.

Still other objects of the invention are to improve generally the efficiency of automatic volume control arrangements, and to provide an improved arrangement which is not only adapted to suppress the reproduction of undesirable sounds in a receiver, but is reliable in operation and economical to manufacture.

The novel features which we believe to be characteristic of our invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which we have indicated one arrangement whereby our invention may be carried into effect.

Referring now to the drawing, wherein is shown diagrammatically a radio receiver of the superheterodyne type embodying an automatic gain control, the novel improvement is illustrated in one of its many possible forms. The receiver circuit is conventional in nature, being well known to those skilled in the art, and comprises an antenna A grounded, as at G, the antenna being coupled, as at M₁, to the tuned input circuit of the first radio frequency amplifier tube 1. The latter is shown as a triode, but may be of the screen grid type, if desired.

The input circuit of the tube 1 is tuned, in the well known manner, by a variable condenser 2, the anode circuit of the tube being energized by the source B. The said anode circuit is cou-

pled, as at M₂, to the tuned input circuit of a second radio frequency amplifier tube 3, thus providing a second stage of tuned radio frequency amplification. The output circuit of tube 3 is coupled, as at M₃, to the tuned input circuit of a first detector tube 4, the latter being arranged for grid leak detection, in the conventional manner, as shown.

The tuning condensers 2 in the two radio stages and detector stage are uni-controlled, and are shown thus by a dotted line. To secure the intermediate difference, or beat, frequency, oscillations, from the local oscillator, are impressed on the input circuit of the detector tube 4, the local oscillations, of course, differing in frequency from the frequency to which the detector stage is tuned, by the said intermediate frequency, and a tuning condenser 2' being of course provided in the local oscillator which is uni-controlled with condensers 2, as is well known in the art.

The output circuit of the tube 4 is coupled, as at M₄, to the input circuit of tube 5, the input circuit being maintained fixedly tuned, by inductance 6 and capacity 7, to the intermediate frequency. The circuit, including the tube 5, acts as an intermediate frequency amplifier, and it is, of course, understood that a plurality of such stages may be employed in cascade. After sufficient amplification of the intermediate frequency, the amplified oscillations are impressed on the input circuit of a second detector tube, through coupling M₅, the input circuit being tuned, by capacity 9, to the intermediate frequency. The tube rectifies the intermediate oscillations by virtue of the well known grid leak detection arrangement shown.

The audio frequency pulsations, in the output circuit of the tube 8, are then amplified by an audio frequency amplifier comprising tubes 10 and 11 connected in cascade, the input circuit of tube 10 being coupled to the detector output circuit by an audio transformer M₆. The output circuit of tube 10 is coupled, by an audio transformer M₇, to the input circuit of power tube 11, and the output circuit of power tube 11 is coupled by transformer M₈ to the reproducer (not shown).

It is to be clearly understood that the receiving circuit just described is well known, and may readily be substituted for in any of its component parts by any other well known parts of a receiver. Furthermore, it should be noted that the reproducer employed may be of any well known type. Again, the operation of the receiver is so well known that from the diagrammatic showing, and the above description, the same is obvious.

Now, in order to maintain the output volume of the receiver at a substantially constant level, an automatic gain control arrangement is employed. This arrangement consists of an electron discharge tube 15 having its control electrode connected by a lead 16, to the control electrode circuit of the second detector tube 8, the lead including a coupling capacity 17. The anode of the control tube 15 includes a stabilizing resistor 18, and is connected by a lead 19 to a point 21 of positive potential (about 90 volts) on the power supply potentiometer 20. The cathode of the control tube 15 is connected, by a lead 22, to the low potential side of the second detector input circuit, and, by a lead 23, to a point 24 on the potentiometer 20, which point is

at a lesser potential (about 45 volts) than the point 21.

The energizing current is derived from a source 25, which is the volume control tube heater, the resistor 25 being tapped by a slidable member 27 and connected to the potentiometer 20, through a resistor 28, the latter being connected in series with the potentiometer resistance. The bias on the control electrode of the control tube 15 can be adjusted by a contact 29, slidable on resistor 28, the contact being connected in series with a resistor 30.

The anode of the control tube is connected, by a lead 31, to the low potential sides of the grid circuits of the radio frequency, and intermediate frequency, amplifier tubes. Blocking condensers 40 are inserted in these amplifier circuits between the cathodes and the tuned circuits. Thus, the anode current of the volume control tube determines the grid bias impressed upon the radio and intermediate amplifier tubes. Those skilled in the art are well aware of the manner of maintaining the cathodes of the controlled tubes at a relatively fixed voltage with respect to the control grids thereof. The present automatic volume control system, as described by G. L. Beers and W. L. Carlson in the Proceedings of the Institute of Radio Engineers for March 1929, page 511, would have the cathodes of the controlled tubes connected to a point which is slightly more positive than the voltage supply to the plate of control tube 15. As stated previously this forms no part of the present invention, and is merely illustrative of one type of automatic volume control arrangement adapted to be used with a radio receiver. Again, the grid potential of the control tube is adjustable by the slidable contact 29 on the resistance 28, and is also affected by the strength of the alternating current voltage fed to the control electrode of the control tube by the signal from the input circuit of the second detector tube 8.

The operation of the automatic volume control arrangement should be obvious from the diagrammatic showing in the drawing, it being pointed out that the automatic gain control arrangement shown herein is well known to those skilled in the art, and may be readily substituted for by any other type of automatic gain control device, such devices, essentially, controlling the sensitivity of the radio or intermediate frequency amplifiers, or both, in an inverse manner relative to the change in intensity level of the signal carrier. Briefly, in the present arrangement when the biasing potential on the control electrode of the control tube 15 is set to any predetermined value, considering of course the carrier signal intensity values, the voltage fed to the control electrode of the second detector is determined, because this determines the anode circuit conditions in control tube 15, and this in turn determines the amplifier grid bias and amplification. It will, thus, be seen that if the signal is removed, the amplification is increased, or in other words the receiver becomes more sensitive, and background noises which may exist are easily reproduced.

It is fundamentally necessary to have the volume control arrangement such that the less the signal intensity, the greater the sensitiveness of the receiver, this being necessary in order to provide the desirable characteristics of automatic volume control, including fading prevention. However, as clearly explained heretofore, it is the purpose of the present invention to provide

an arrangement whereby when no signal at all is present, or one too weak to be useful, the sensitivity of the receiver shall be reduced, or, at least, that the reproduction of background noise shall be reduced or eliminated, by rendering the signal translating device of the receiver inefficient, or perhaps inoperative. By the term signal translating arrangement, is meant not only the reproducer device, but also any of the element or elements subsequent in the circuit to arrangements whose function is merely to amplify high frequency oscillations. Thus, the detector circuit, the audio amplifier circuit and the immediate reproducer circuit would be encompassed within the expression "signal translating device."

The particular arrangement shown in the drawing for rendering the signal translating arrangement inefficient whenever the signal carrier intensity decreases below a predetermined intensity level, depends upon the fact that the value of anode current of all the radio frequency and intermediate frequency tubes depends upon the signal carrier strength. For example, in the type of superheterodyne receiver shown in the drawing, this current is from two milliamperes to 15 milliamperes. Thus, in this particular receiver, when the anode current reaches some value between 10 and 15 milliamperes, the signal is no longer of practical usefulness. Therefore, an overload relay, set to operate at a predetermined value, for example 13 milliamperes, is provided, the relay being arranged to render the reproducer inoperative whenever the carrier intensity level becomes too low to be of any value. Again, the reproducer becomes operative only when there is sufficient signal strength to reproduce satisfactorily, without the reproduction of background noises.

Specifically, these results are accomplished by connecting a mechanical relay device between the output circuit of the intermediate frequency amplifier, preferably the last intermediate stage, and the reproducer. The relay consists of a solenoid electromagnet 40 connected in series with the anode circuit of tube 5, a condenser 43 being connected across the solenoid 40 to by-pass high frequency currents, and having a value suited to the frequency employed.

The direct current flowing through the electromagnet is, therefore, the anode direct current of tube 5, and the arrangement is so shown for the sake of simplicity of diagram. The circuit could be arranged, as would ordinarily be done in practice, so that the electromagnet would receive the combined anode currents of all of the tubes whose amplification is controlled by the automatic volume control means. In the diagram, this would be the total anode currents of tubes 1, 3 and 5. Use of the combined currents would permit use of a relay operable on larger currents, and therefore a less expensive or more reliable one.

The armature 44 of the electromagnet 40 is pivoted at 45, and connected by a lead 46 to one side of the secondary of the output transformer Ms. The element 47, which is adapted to contact with the armature to short-circuit the secondary of the output transformer when the armature 44 is attracted towards the electromagnet 40, is connected by a lead 48 to the other side of the power transformer secondary, through a resistance 49.

A stop 50 is disposed in alignment with the contact member 47, the armature head 51 being disposed between the two. A capacity 52 may be

connected across the output transformer secondary, and given a value suitable to the particular transformer and reproducer used, to eliminate sparking at the contacts 47, 51, this sparking being readily picked up by the receiver as interference clicks when the contacts open or close, unless guarded against in the manner shown. The resistance 49 has a value depending upon the particular transformer and reproducer used, and the degree of inefficiency of translating device desired. If the magnitude of this resistance is made zero, the sound reproducer will be short circuited when the relay contacts are closed, and will therefore be absolutely silent when no carrier is being received.

The armature 44, of the electromagnet 40, is normally tensioned by a spring 60, means being provided to vary the tension of the spring, (such means being conventionally shown by an arrow adjacent the fixed end of the spring) it thereby being possible to adjust the relay to operate at the desired current. It is pointed out that the specific arrangement shown herein is not in any way limiting, and that the relay device may be connected between the reproducer and the plate circuit of any of the radio frequency amplification stages or intermediate frequency amplification stages.

The relay device 40, 44 should preferably be a "time-relay", so that it will actuate only as the current change which is desired to actuate it, has persisted for a certain length of time. In this way unnecessary short-circuiting of the reproducer is prevented, as for example during the process of tuning in a desired signal. The operation of the background noise suppressor employed herein will be obvious from the arrangement as shown in the drawing, and from the following specific explanation.

In the radio and intermediate frequency tubes, the values of anode current flowing depend upon the grid voltage values. The grid voltage values are determined by the automatic volume control tube or other automatic volume control means, in line with the normal operation of usual automatic volume control arrangements. The automatic volume control tube has its effect determined by the strength of the signal carrier fed to it.

Therefore, there is a direct relation between signal carrier strength and the value of anode current flowing in the tube or tubes controlled by the automatic volume control means. Usually this relation is that the stronger the carrier the smaller the anode current. In the diagram shown, tube 5 might have, for example, a current of three milliamperes when no signal was being received. This current would flow through the electromagnet 40 of the relay. When a signal carrier is tuned in, its voltage appearing in the input circuit of tube 8 would also be applied to the grid of tube 15, whose anode current flowing through resistance 18 would be changed thereby.

The change in anode current through resistance 20, produces a change in the potential applied to the grids of the amplifier tubes through lead 31. The change in potential of these grids changes the amplifying ability of these tubes, and also the values of anode current in them. Therefore, the relations are such that the signal carrier automatically adjusts the amplifying ability of the amplifier to deliver a substantially constant radio frequency voltage output to the detector tube 8. In so doing however it causes changes in the anode direct currents. In the

example shown, where the anode current of tube 5 may be 3 milliamperes when no signal is being received, the anode current may, for example, be reduced to 2.0 milliamperes when a signal carrier of moderate strength is received, and 2.5 milliamperes when a very weak carrier is received.

Assuming that considerable interference is present, the signal accompanying the 2.5 milliamperes current may be useless. Therefore, complete operation of the receiver is desirable when this current is less than 2.5 milliamperes and no operation is desired when this current exceeds 2.5 milliamperes. If we employ a relay so adjusted that it will close and make contact between elements 47 and 51 when the current exceeds 2.5 milliamperes, and opens when the current is less than 2.5 milliamperes, the desired operation will be achieved, and the receiver will be operative in the presence of signals stronger than the predetermined desired value, and inoperative on weaker signals or no signals. Interference noises function as no signals, in effect on the relay, because of their intermittent nature, and so are eliminated as the receiver is rendered inoperative when they only are incoming. Means may be provided for adjusting the relay operation point (2.5 in the above example) to any value suited to particular reception conditions.

The salient points in the operation of noise suppression are:

(a) When the receiver is tuned to a signal carrier, noise suppression is not desired or needed, and the suppression arrangement must be such as to leave incoming signals unaffected.

(b) When the receiver is not tuned to a signal carrier, only interference noises pass through the receiver and are reproduced as unpleasant sounds, unless suppressed. It is desired to suppress these sounds.

(c) Current conditions in certain parts of the receiver circuit are different when signal carrier is present from conditions when signal carrier is absent. Therefore these changes in current can be utilized to bring a noise suppression means into operation.

(d) These current changes can effect noise suppression by being arranged to render the receiver inoperative or inefficient at some point in its circuit beyond that part wherein the current changes themselves exist.

(e) In the particular arrangement previously described in detail, the current changes operate a relay whose contacts short circuit the reproducer, and the arrangement is, of course, not limiting in scope.

Wherever the use of a solenoid relay is not practicable, it is to be understood that other means may be employed as a substitute therefor, or in conjunction therewith. For example, an electron discharge relay may be employed in conjunction with the mechanical relay the anode current change of the electronic relay being utilized to actuate the solenoid relay as shown in the drawing. However, a solenoid relay will be found practicable whenever the anode current is sufficiently different under the two conditions of signal on and off, and has enough magnitude to actuate a solenoid relay of practicable design. Again, instead of short-circuiting the output transformer secondary or the voice coil of the reproducer, the relay can be readily employed for opening or closing the reproducer circuit, or for controlling means for rendering any of the signal translating elements inefficient in reproduction.

While we have indicated and described one ar-

range for carrying our invention into effect, it will be apparent to one skilled in the art that our invention is by no means limited to the particular organization shown and described, but that many modifications may be employed without departing from the scope of our invention as set forth in the appended claims.

What we claim is:

1. A signaling system comprising a high frequency amplifier circuit, means for tuning said circuit to a desired frequency, a gain control device for regulating the sensitivity of said amplifier, means for utilizing the amplifier output, and additional means connected directly in the amplifier circuit for automatically decreasing the utilizing efficiency of said last means when said amplifier is adjusted to maximum sensitivity by said gain control device but less than a predetermined amount of high frequency energy is received.

2. A signaling system comprising a high frequency amplifier circuit, means for tuning said circuit to a desired frequency, a gain control device for regulating the sensitivity of said amplifier, means for changing the frequencies amplified at high frequency to a low frequency, a low frequency amplifier, and additional means directly responsive to current flow in said high frequency amplifier circuit for automatically impairing the transmission efficiency of the low frequency amplifier when the high frequency amplifier is adjusted to substantially maximum sensitivity by said gain control device but no high frequency energy is received.

3. In combination in a radio receiver, means for tuning the receiver, a signal translating means, and additional means, including an electrical relay responsive to a predetermined decrease in carrier intensity, for short-circuiting the signal translating means during tuning of the receiver through points on the frequency scale where said decrease occurs.

4. A signaling system comprising a high frequency amplifier circuit, means for tuning said circuit through a range of frequencies, a gain control device for regulating the sensitivity of said amplifier, means for changing the frequencies amplified at high frequency to a low frequency, a low frequency amplifier, and additional means responsive to said regulated amplifier for automatically impairing the transmission efficiency of the low frequency amplifier when the high frequency amplifier is adjusted to substantially maximum sensitivity by said gain control device but is tuned through a point of the range where no high frequency energy is received.

5. A receiving system comprising a signal translating device, a radio frequency amplifier connected to the device, means for regulating the sensitivity of said amplifier inversely with received signal energy level, and means, operative to disable said device, when said amplifier is adjusted to substantially maximum sensitivity by said regulating means and no signal energy is received said disabling means being connected directly in the amplifier circuit and being responsive to its sensitivity regulation.

6. In combination, in a superheterodyne radio receiver, a radio frequency amplifier, a frequency changing means, a low frequency amplifier, means for controlling the gain of the radio frequency amplifier, and an electrical relay, responsive to variations in the output of said frequency changing means, for reducing the transmission efficiency of the low frequency amplifier when the

gain of the radio frequency amplifier is increased by said controlling means and no carrier wave is received.

7. In combination, in a superheterodyne radio receiver, a radio frequency amplifier, a frequency changing means, a low frequency amplifier, means for controlling the gain of the radio frequency amplifier, and an electrical relay, responsive to variations in the output of said frequency changing means, for reducing the transmission efficiency of the low frequency amplifier when the gain of the radio frequency amplifier is increased and no carrier wave is received, said relay being connected between the frequency changing means and the output of said low frequency amplifier.

8. In combination, in a radio receiver, a radio frequency amplifier, a frequency changing means, a low frequency amplifier, means for controlling the gain of the radio frequency amplifier, and an electrical relay, responsive to variations in the output of said frequency changing means, for reducing the transmission efficiency of the low frequency amplifier when the gain of the radio frequency amplifier is increased and no carrier wave is received, said low frequency amplifier including an output transformer, and said relay being connected to short-circuit the transformer secondary.

9. A superheterodyne receiver comprising a radio frequency amplifier, means for tuning the amplifier to a desired frequency in a range of frequencies, a frequency changing device, an intermediate frequency amplifier, a second frequency changing device, an audio frequency amplifier, means for connecting said last amplifier to a reproducer, an automatic gain control circuit connected between the second frequency changing device and said radio frequency amplifier, and an electrical relay, connected between the output of said intermediate amplifier and said audio frequency amplifier, for reducing the transmission efficiency of the audio frequency amplifier when the radio frequency amplifier is adjusted for increased gain but is tuned through a point where no carrier wave is being received.

10. In a receiver for modulated carrier waves, a signal frequency amplifier, means for producing audio frequency voltage by rectification of amplified signals, means for producing direct current voltage by rectification of amplified signals, means for amplifying the said audio frequency voltage, means actuated by said direct current voltage to control the gain of said signal amplifier, and means, in said signal amplifier circuit directly responsive to signal amplifier current for suppressing the amplification of said audio frequency voltage, for impressed signal voltages below a predetermined value.

11. In a system for the transmission of modulated signals, the combination with an amplifier for amplifying said signals, and means automatically controlling the gain of said amplified in accordance with the strength of received signals,

of a demodulator, a reproducer for the demodulated signals, and means directly responsive to said amplifier current, operative simultaneously with said gain control means during periods of operation of the latter, to substantially prevent the reproduction of all output from said demodulator when said signals decrease below a predetermined intensity value.

12. In a radio receiver of the type including a radio frequency amplifier having a tuned input network, an electron discharge tube demodulator and an audio frequency utilization network, automatic gain regulation means, responsive to variations in amplitude of signals impressed on the demodulator tube input, for decreasing the gain of said amplifier as the said amplitude increases, and audio transmission efficiency control means including an electrical relay, said relay being directly responsive to said variations and being connected to said audio utilization network in such a manner that the transmission efficiency of the utilization network is substantially impaired when said amplifier gain is substantially a maximum.

13. In a signal receiving system of the type comprising means responsive to change in the strength of a received signal for automatic volume control, tuning and demodulating means, background noise suppressing means and means whereby the background suppressing means is controlled from the automatic volume control means.

14. The invention set forth in claim 13, characterized in that further means are provided for so adjusting the background noise suppressing means that it may be rendered insensitive to signals of less than a predetermined amplitude.

15. In a system for the reception of energy, a receiver having a detector normally in operative condition, a demodulated signal output path associated therewith and normally maintained in a condition of disability, means adapted to regulate the gain of said receiver, and means for removing the disability from said demodulated signal output path, said last-named two means having a common element controlled by the carrier energy transmitted to said receiver and means whereby the second means is controlled from the gain regulation means.

16. In a carrier frequency signaling system tunable over a range of carrier frequency channels, an arrangement for suppressing interchannel disturbances and weak signals, comprising means for rendering said system inoperative when the signal strength is below cut-off level, signal responsive means for disabling said first means thereby rendering said system operative when the signal strength rises above said cut-off level, and adjustable means for selecting said cut-off level.

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