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CONTROL CIRCUITS

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Fig. 1.

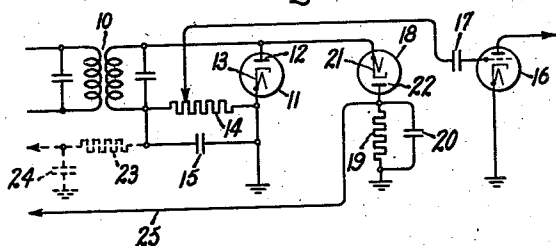


Fig. 2.

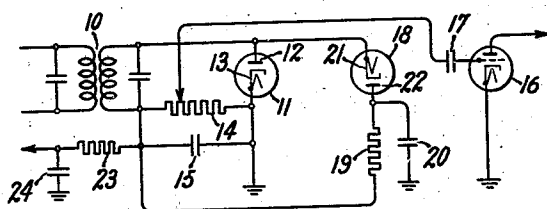


Fig. 3.

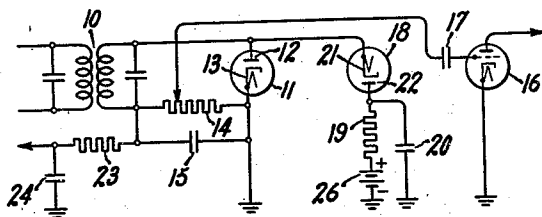


Fig. 4.

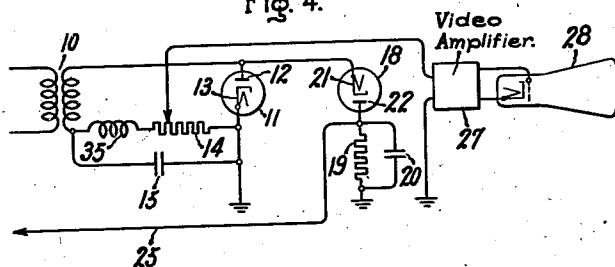
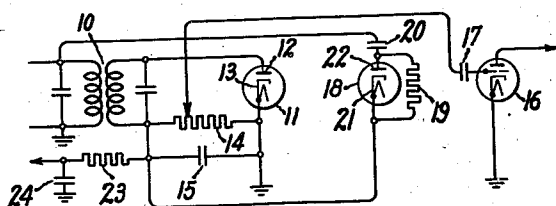


Fig. 5.



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UNITED STATES PATENT OFFICE

2,298,083

CONTROL CIRCUITS

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14 Claims. (Cl. 250—20)

My invention relates to control circuits particularly adapted for use in radio or television receiving apparatus.

One of the main objects of my invention is to provide improved noise suppression circuits which effectively discriminate between undesired noise impulses and desired signals and prevent such impulses from appearing in the output of radio or television receiving apparatus.

Another object of my invention is to provide improved control circuits for preventing noise transients from appearing in the receiver output whenever these transients exceed a threshold level which is automatically determined by the carrier level of the received signal as well as its modulation level.

A further object of my invention is to provide improved control circuits which may perform the dual function of noise suppression circuits and voltage doubling automatic gain control circuits.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 diagrammatically represents a portion of the circuits of a radio receiving apparatus embodying my invention; Figs. 2 and 3 represent modifications of the circuits of Fig. 1; Fig. 4 diagrammatically represents a portion of the circuits of a television receiving apparatus embodying my invention; and Fig. 5 represents a further modification of my invention.

In the several figures, corresponding reference numerals have been placed on corresponding elements to facilitate their comparison.

The radio receiver circuits of Fig. 1 include a detector 11 and an amplifier 16. These may be, for example, the second detector of a superheterodyne radio receiver and the first audio frequency amplifier. High frequency carrier waves, modulated by desired audio signals, are supplied from any suitable signal receiving apparatus (not shown) to the detector input through the tuned input transformer 10. The signal detector 11 is of the diode type, having an anode 12 and cathode 13. The signal detector circuit extends from the anode 12 through the secondary of the input transformer 10, a diode load resistor 14 and high frequency by-pass capacitor 15 in parallel, to the cathode 13.

The operation of this portion of the circuit is well known to those skilled in the art and will

not be detailed here. The detector is effective to demodulate the carrier waves impressed upon the transformer 10. In a superheterodyne receiver these carrier waves will generally be of an intermediate high frequency lower than the carrier frequency of the received signals. The demodulation products developed across the diode load resistor 14 include audio frequency components and a direct current component. The audio frequency components are coupled to the grid of the audio frequency amplifier 16 through the coupling capacitor 17. The amplified signal voltages appearing in the output of the amplifier 16 are supplied to any suitable utilization circuit (not shown). This may comprise a further stage of audio amplification or a sound translating device.

As is well known, interfering electrical disturbances of short duration and considerable magnitude are often received on the signal channel along with the desired signal. These may seriously distort the desired signal, or even mask it completely, whenever they approach or exceed the magnitude of the useful signal. Such disturbances are generally grouped under the term "impulse noise," as distinguished from "hiss" or "thermal agitation noise." These disturbances may arise from various causes. For example, natural atmospheric static surges, man-made electrical disturbances, as from high frequency apparatus, ignition systems and the like, and other sharp impulses fall within this category. The characteristics of these undesired noise impulses may vary widely, depending upon their source, but in all cases they have a deleterious effect upon the fidelity of signal reproduction, either by direct interference with the signal, or through shock excitation effects in the receiving system.

In order to limit the effect of such noise impulses, a noise suppression network is provided in accordance with my invention. As shown in Fig. 1, this network includes a second diode detector 18 reversely connected in parallel to the signal diode 11 through a resistor 19 shunted by a capacitor 20. The time constant of the network 19, 20 is selected so as to be relatively long as compared to the period of the lowest signal frequency within the band of frequencies which it is desired to transmit to the audio frequency amplifier 16. For example, it may be of the order of about one-tenth of a second. Further, the resistor 19 has a very high value as compared to diode load resistor 14. For example, it may be of the order of about ten megohms with a 50,000 ohm diode load resistor. This network functions

to reduce the interfering effects of noise impulses in a manner now to be described.

It will be observed that the diode 18 is in circuit with the secondary winding of the transformer 10 and the output network 14, 15 and that it is poled to pass current through these elements, when conductive, in the opposite direction from current flowing in the signal diode circuit. Thus, this circuit extends from the anode 22 of the diode 18, through the network 19, 20, the network 14, 15 and the secondary winding of transformer 10, to the cathode 21.

The signal diode 11 passes current on the peaks of those half cycles of the applied carrier wave which make its anode positive, and the modulation voltages appearing on the network 14, 15 reproduce the modulation envelope. On the peaks of alternate half cycles, the maximum voltage across the diode 11 is approximately equal to the sum of the maximum diode load voltage on the network 14, 15, and the peak voltage of the applied carrier waves. These two voltages are approximately equal and hence the peak voltages applied across the diode 18 and network 19, 20 are approximately equal to twice the peak amplitude of the carrier waves.

Due to the relatively long time constant of the network 19, 20 the diode 18 functions as a rectifier on the outward peaks of audio modulation and charges the capacitor 20 up according to the peak values of the signal and modulation levels. The diode 18 therefore draws only the small current necessary to replenish the charge on the capacitor 20 which leaks off through the resistor 19. The potential on capacitor 20 varies with the modulation envelope so that noise peaks can be limited substantially at the audio peak level. At zero modulation, or very low levels of modulation, limiting takes place approximately at the carrier level. The bias potential on diode 18 thus may vary between approximately two and four times the unidirectional component of the carrier voltage developed on load resistor 14.

Assume now that an undesired noise impulse of greater magnitude than the audio modulation and of short duration is impressed on the secondary of the transformer 10. A low impedance path for voltages of either polarity is now provided through one or the other of the two diodes, since the diodes are reversely connected to pass current through the output load resistor 14 in both directions and capacitor 20 is of low impedance for impulses which are conducted by diode 18. Therefore, since no demodulation of the noise transient takes place, it is effectively suppressed, producing substantially no effect upon the grid of the amplifier 16.

The internal resistance of the signal diode 11 should be approximately equal to the internal resistance of the diode 18. In a particular radio receiver embodying my invention, values of about 10 megohms for resistor 19 and about .01 microfarad for capacitor 20 were found to be suitable.

It is common practice to utilize the direct current component of the demodulated signals appearing on resistor 14 for automatic gain control. Conventional connections are shown in dotted outlines in Fig. 1. Unidirectional potentials, negative with respect to ground, are developed at the left-hand end of resistor 14 and applied through a low-pass filter, comprising a resistor 23 and capacitor 24, to the gain control connections of preceding stages of the receiver, not shown. The arrangement and operation of the gain control connections will readily be un-

derstood by those skilled in the art without elaboration. The potentials are applied to control electrodes of one or more of the tubes preceding the detector to reduce the receiver gain in accordance with the strength of the received signals, as is well understood in the art.

Since the bias voltages developed across the resistor 19 and capacitor 20 are approximately twice those appearing on resistor 14, the noise suppression circuit can be utilized to perform the additional function of a voltage-doubling automatic gain control circuit. Thus a more effective gain control action may optionally be secured by connecting the upper end of resistor 19 to the gain control connections over conductor 25. Further, the resistor 19 and capacitor 20 serve as a low-pass filter, eliminating the need for additional filter means.

A small amount of signal distortion must inevitably be caused by the limiter circuit due to the intermittent charging current drawn by network 19, 20. High fidelity reproduction requires a very low order of harmonic distortion. A circuit which reduces signal distortion to a negligible value although with some reduction in the noise suppression action is illustrated in Fig. 2. It will be observed that it differs from the noise suppression circuit of Fig. 1 only in that the lower end of resistor 19 is connected to the left-hand end of resistor 14 rather than directly to ground. The potential on resistor 19, and therefore the discharge current, is now reduced by approximately one-half. This is apparent from the fact that the maximum voltage impressed on diode 18 and resistor 19 is now only the peak value of the carrier waves supplied from transformer 10 and does not include the approximately equal voltage developed on resistor 14. The discharge circuit for capacitor 20 now includes resistors 14 and 19 in series, but since the former is so much smaller than the latter, the time constant of the network on discharge is not materially altered. Noise transients which are of a polarity to make diode 18 conductive still find a low impedance path to the grounded end of resistor 14 through capacitor 20, as is the case in the circuit of Fig. 1. Satisfactory results have been obtained in an audio detection circuit having values of twenty megohms for resistor 19 and .01 microfarad for capacitor 20.

In voice-communication work where intelligibility of the received signals is the primary desideratum, the noise-suppression circuit of Fig. 3 provides improved noise suppression, especially on weak signals. This is secured at some sacrifice of fidelity over the circuits previously described, but it is possible to eliminate impulse noise almost entirely. The circuit is again essentially the same as that of Fig. 1 and fundamentally operates in the same manner. The only change is in the addition of a source of low potential to the noise suppression circuit, illustrated as a battery 26. The source is poled to produce a small current flow through the diode 18. Generally, the potential value is not critical. Five or ten volts have been found satisfactory in a typical receiver circuit.

The addition of the battery 26 increases the speed of recovery of the noise-suppression circuit after a noise impulse, particularly for weak signal reception, since it assists in discharging capacitor 20. Without the battery 26, a weak signal may be masked by noise since repeated impulses may sustain a potential on capacitor 20 well above the limiting level.

In Fig. 4 my invention is shown in connection with the final picture signal circuits of a television receiver. The signal detection and noise suppression circuits, which are shown in detail, are essentially the same as the circuits of Fig. 1 and corresponding elements have been supplied with corresponding reference numerals. The demodulated video signals appearing upon the load resistor 14 are supplied to a video amplifier, indicated schematically by the block 27, and thence to a cathode ray device 28 of the usual type employed in such circuits for reproducing the picture image. The synchronizing and sweep circuits of the receiver have been omitted to simplify the drawing, as they form no part of my invention.

The functions of the signal detection and noise suppression circuits of the television receiver of Fig. 4 are fundamentally the same as previously described in connection with the circuits of Fig. 1. The principal difference resides in the choice of circuit constants for proper reproduction of the much wider band of signal frequencies, which may extend from about 60 cycles to 4 megacycles or higher. A series peaking inductance 35 is connected in circuit with the output load resistor 14 for improving the high frequency response of the detector circuit in a manner familiar to those skilled in the art.

The positive modulation peaks of the carrier correspond to the peaks of the synchronizing pulses in one form of television transmission system in current use. In the television receiving apparatus of Fig. 4 noise impulses will be limited substantially to this level. In a particular television receiver embodying my invention it was found that line and frame synchronization was improved on weak signals in the presence of noise, thereby demonstrating the practical utility of my improved circuit.

The noise suppression circuit of Fig. 4 may also be utilized to provide a voltage-doubling automatic gain control action. The gain control connections of the preceding stages of the television receiver, not shown, may be supplied with control potentials over the conductor 25. This is particularly effective in video circuits since the peak amplitude of the television signals is constant in the aforesaid system of transmission. Rectification in diode 18 therefore takes place only on the fixed level of the synchronizing pulses and the gain control potentials will be proportional to this level.

A further modification of my invention embodied in a radio receiving apparatus is illustrated in Fig. 5. The signal detection circuit is the same as before, but the noise detection circuit is supplied with high frequency potentials from the primary winding of the input transformer 10, rather than from the secondary winding, as in the circuits described heretofore. An alternative connection of the noise diode 18, resistor 19, and capacitor 20 is also shown, the resistor 19 being connected in shunt to the diode 18 rather than the capacitor 20. The detection action of this form of noise suppression circuit is not substantially different from the circuits previously described, as will be understood by those skilled in the art without detailed analysis.

The diodes 11 and 18 in Fig. 5 are poled to pass current through the diode load resistor and capacitor 14 in opposite directions, when conductive, as before. The maximum voltage on diode 18 is the sum of the maximum diode load voltage on the network 14, 15 and the peak volt-

age on the primary winding of transformer 10, in this case. If desired, noise impulses may be impressed simultaneously on the signal diode 11 and on the noise diode 18 in the conductive direction, depending upon the direction of winding the primary of transformer 10 with respect to the secondary.

It may be found desirable, in some cases, to supply the signal and noise detector circuits with high frequency potentials from two separate secondary windings on the transformer 10, both being coupled to a common primary winding. As in the case of Fig. 5 this permits a choice of polarities for the individual secondary windings to secure most effective noise suppression action. Furthermore, the tuning characteristics for the input circuit of the signal diode may be made different from those of the input circuit for the noise diode so as to provide more effective suppression of noise impulses in the signal diode load circuit 14, 15.

It will thus be apparent that I have provided improved noise suppression and automatic gain control circuits which require a minimum of elements and which are readily adapted to existing apparatus. While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination with a source of signal-modulated high frequency potentials subject to interfering noise impulses, a signal detector circuit serially comprising a unilaterally conducting discharge device and an output impedance adapted to have demodulated signal potentials developed thereon, a second detector circuit serially comprising a second unilaterally conducting discharge device having an anode and a cathode, said output impedance and a second impedance, said devices being poled to pass current through said output impedance in opposite directions when conductive, means coupled to said source for impressing said high frequency potentials on both of said circuits in parallel, and peak rectifying means including said second device and second impedance for biasing said anode negatively with respect to said cathode, said last means being operative at all times to effect peak rectification of both said high frequency potentials and said demodulated potentials, said second device and second impedance having a low impedance for impulses which exceed said bias and which are of a polarity to drive said cathode negative, whereby impulses of either polarity exceeding said bias find a conducting path through said output impedance and through one or the other of said devices.

2. In combination with a source of signal-modulated high frequency potentials subject to interfering noise impulses, a signal detector circuit coupled to said source and serially comprising a unilaterally conducting discharge device and an output impedance adapted to have demodulated signal potentials developed thereon, a second detector circuit coupled to said source in parallel to said signal detector circuit and serially comprising said output impedance, a capacitor, and a second, reversely connected unilaterally conducting discharge device having an anode and a cathode, a resistor connected from the

junction between said second device and said capacitor to another point on said second circuit, and peak rectifying means comprising said second device, said capacitor and said resistor for biasing said anode negatively with respect to said cathode, said means being operative at all times to effect peak rectification of both said high frequency potentials and said demodulated potentials, said second device and said capacitor having a low impedance for noise impulses which exceed said bias and which are of a polarity to drive said cathode negative, whereby impulses of either polarity exceeding said bias find a conducting path through said output impedance and through one or the other of said devices.

3. In combination with a source of signal-modulated high frequency potentials subject to interfering noise impulses, a signal detector circuit serially comprising said source, a unilaterally conducting discharge device, and an output impedance across which demodulated signal potentials are developed, a second detector circuit serially comprising said source, said output impedance and a second, reversely connected, unilaterally conducting discharge device having an anode and a cathode, said circuits being energized in parallel from said source, and rectifying means including said second device for biasing said anode negatively with respect to said cathode, said means being operative at all times to effect peak rectification of both said high frequency potentials and said demodulated potentials, said second device having a low impedance for impulses which exceed said bias and which are of a polarity to drive said cathode negative, whereby impulses of either polarity exceeding said bias find a conducting path through said output impedance and through one or the other of said devices.

4. In combination with a source of carrier waves modulated in amplitude in accordance with a band of signal frequencies and subject to undesired noise transients, a signal detection circuit serially including a rectifying device, a signal output impedance and said source, a second rectifying device reversely connected across said first device through connections including a network having a resistance element and a capacitance element, said network having a relatively long time constant as compared to the period of the lowest signal frequency in said band, and means comprising said second device for developing at all times a negative self bias through peak rectification of the waves impressed thereon, said second device being conductive to pass current through said output impedance only in response to transients of one polarity which exceed said bias.

5. In combination with a source of signal-modulated high frequency potentials subject to interfering noise impulses, a signal detector circuit serially comprising an input impedance coupled to said source, a rectifying device and an output impedance adapted to have demodulated signal potentials developed thereon, a second detector circuit serially comprising a second input impedance coupled to said source, a second rectifying device having an anode and a cathode, a capacitor and said output impedance, said circuits being energized in parallel from said source and said devices being poled to pass current through said input impedance in opposite directions when conductive, and peak rectifying means including said device and said capacitor for biasing said anode negatively with respect to

to said cathode, said means being operative at all times to effect peak rectification of both said high frequency potentials and said demodulated potentials, said second device and said capacitor having a low impedance for impulses which exceed said bias and which are of a polarity to drive said cathode negative, whereby impulses of either polarity exceeding said bias find a conducting path through said output impedance.

6. In a modulated wave receiver for operation on carrier waves modulated over a band of signal frequencies and subject to interfering noise transients, the combination comprising a signal detection circuit serially including an input impedance, a signal rectifier and an output resistor by-passed for carrier frequencies, a noise suppression diode having an anode and cathode reversely connected across said signal diode through a capacitance element, and a resistance element of high resistance as compared to said output resistor connected in shunt to said capacitance element through a source of low unidirectional potential, said elements having a relatively long time constant, said source being poled to bias said anode positively.

7. In a modulated wave receiver for operation on carrier waves modulated over a band of signal frequencies, said receiver having connections for varying the receiver gain in accordance with gain control potentials applied thereto, a signal demodulating circuit serially including an input impedance, a signal diode and an output load impedance by-passed for carrier frequencies, a second diode reversely connected across said signal diode through connections serially including a resistance element shunted by a capacitance element, said elements having a relatively long time constant as compared to the period of the lowest signal frequency in said band, peak rectifying means comprising said second diode and said elements for developing potentials across said elements substantially corresponding to the peak values of the waves appearing across said detector diode, and means for applying said potentials to said gain control connections to reduce the receiver gain.

8. In a modulated wave receiver for operation on carrier waves modulated over a band of signal frequencies and subject to interfering noise transients, said receiver having connections for varying the receiver gain in accordance with gain control potentials applied thereto, a signal demodulating circuit serially including an input impedance, a unilaterally conducting discharge device and an output impedance across which demodulated signals are developed, a second unilaterally conducting discharge device having an anode and a cathode and being reversely connected across said first device through connections serially including a resistance element shunted by a capacitance element, said elements having a relatively long time constant, as compared to the period of the lowest signal frequency in said band and peak rectifying means comprising said second device and said elements for developing potentials on said elements, through peak detection of the waves appearing on said first device, which bias said anode negatively with respect to said cathode, said second device having a low impedance for noise transients which exceed said bias and which are of a polarity to drive said anode positive, and means for applying said potentials to said gain control connections to reduce the receiver gain.

9. In combination with means for supplying waves modulated in amplitude by desired signal voltages and subject to undesired noise interference, a signal detection circuit coupled to said means comprising a unilaterally conducting device and an impedance adapted to have the demodulated signal voltages developed thereon, a noise suppression circuit coupled to said means comprising said impedance, a second unilaterally conducting device and a time constant network, said circuits being energized in parallel from said source and said devices being poled to pass current through said output impedance in opposite directions when conductive, and means including said second device and said network for developing a negative bias for said second device substantially corresponding to the peak modulation level of said waves for all values thereof.

10. In combination with means for supplying high frequency carrier waves modulated in amplitude by desired signal frequency waves and subject to undesired noise transients, a signal detection circuit coupled to said means comprising a rectifying device and a load resistor by-passed only for carrier frequencies, a noise suppression circuit coupled to said means comprising said load resistor, a second rectifying device and a resistance-capacitance network having a time constant longer than the period of the lowest desired signal frequency, said circuits being energized in parallel from said source and said second device being poled to pass current through said load resistor in the opposite direction from said first device when conductive, and means comprising said second device and said network for impressing a negative bias on said second device substantially corresponding to the peak modulation level of said carrier waves for all values thereof, whereby transients of one polarity exceeding said bias are conducted by said noise suppression circuit.

11. In radio receiving apparatus for translating carrier waves modulated over a band of desired signal frequencies and subject to undesired transient interference, means for supplying said waves to an input impedance, a signal demodulating circuit serially including said input impedance, a signal detector and an output load resistor by-passed only for carrier frequencies, a noise suppression circuit serially including a noise detector reversely connected across said signal detector through a resistance-capacitance network having a time constant longer than the period of the lowest desired signal frequency in said band, means comprising said noise detector and said network for impressing a negative bias on said noise detector substantially corresponding to the peak modulation level of said carrier waves for all values thereof, whereby transients of one polarity exceeding said bias are conducted by said noise suppression circuit.

12. In combination with means for supplying carrier waves modulated by desired signal waves and subject to undesired noise interference, a signal detection circuit serially comprising said

means, a signal detector and an output impedance adapted to have the demodulated signals developed thereon, a noise suppression circuit serially comprising said means, said impedance, a noise detector and a capacitance, said circuits being energized in parallel from said means and said detectors being poled to pass current through said output impedance in opposite directions when conductive, a resistance and a source of unidirectional potential connected in series across said capacitance, and means comprising said noise detector, said capacitance and said resistance for impressing a negative bias on said noise detector substantially corresponding to the peak modulation level of said carrier waves, said source being poled to oppose said bias.

13. In radio receiving apparatus for translating carrier waves modulated over a band of desired signal frequencies and subject to undesired transient interference, means for supplying said waves to an input impedance, a signal demodulating circuit serially including said input impedance, a signal detector and an output load resistor by-passed only for carrier frequencies, a noise suppression circuit serially including a noise detector reversely connected across said signal detector through a capacitance element, and a resistance element of high resistance as compared to said load resistor connected in shunt to said capacitance element through a unidirectional bias source, said elements having a time constant long as compared to the period of the lowest desired signal frequency in said band, and means comprising said noise detector and said elements for impressing a negative self-bias on said noise diode substantially corresponding to the peak modulation level of said carrier waves, and said fixed bias source being poled to oppose said self-bias.

14. In radio receiving apparatus for translating high frequency waves modulated over a band of desired signal frequencies and subject to undesired transient interference, said apparatus having connections for varying the gain in response to gain control potentials impressed thereon, means for supplying said waves to an input impedance, a signal demodulating circuit serially including said input impedance, a signal rectifier and an output load resistor by-passed only for said high frequency waves, a noise suppressing and voltage-doubling gain control circuit serially including a second rectifier reversely connected across said signal rectifier through a resistance-capacitance network having a time constant longer than the period of the lowest desired signal frequency in said band, said noise suppressing and gain control circuit being effective to develop potentials on said network which bias said rectifier negatively substantially in accordance with the peak modulation level of said high frequency waves for all values thereof, and means for impressing said potentials upon said gain control connections.

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