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G. W. FYLER
NOISE LIMITING CIRCUIT

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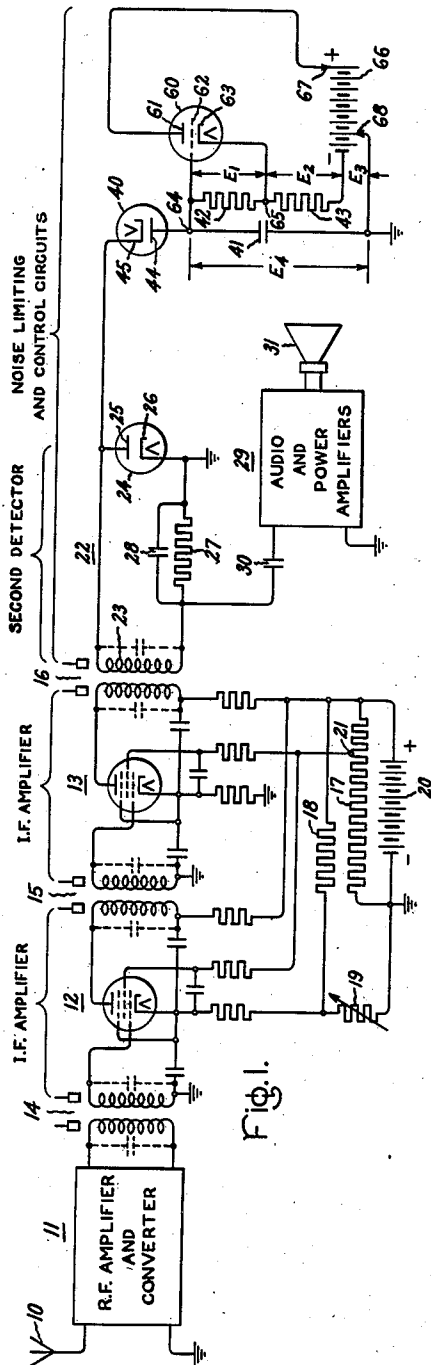


Fig. 1.

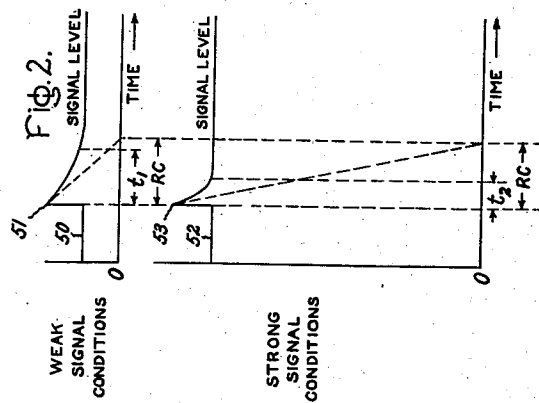


Fig. 2.

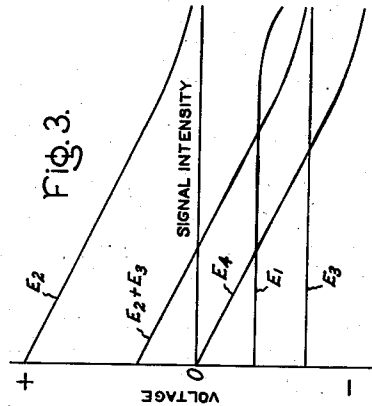


Fig. 3.

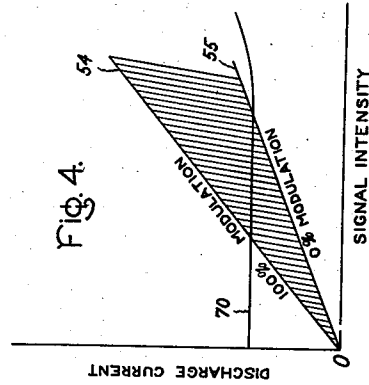


Fig. 4.

Inventor:
George W. Fyler,
by *Harry E. Dunkley*
His Attorney.

UNITED STATES PATENT OFFICE

2,298,084

NOISE LIMITING CIRCUIT

George W. Fyler, Stratford, Conn., assignor to
General Electric Company, a corporation of
New York

Application June 14, 1941, Serial No. 398,088

15 Claims. (Cl. 250—20)

My invention relates to a noise limiting circuit particularly adapted for use in radio receiving apparatus.

This application is a continuation-in-part of my application Serial No. 364,160, filed November 4, 1940, and assigned to the same assignee as the present invention.

It is an object of my invention to provide an improved noise limiting circuit which effectively discriminates between undesired noise impulses and desired signals impressed on the input of radio receiving apparatus and which prevents such impulses from appearing in the output circuits of the apparatus.

Another object of my invention is to provide an improved noise limiting circuit 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.

Another object of my invention is to provide an improved noise limiting circuit of this general type which is equally effective in suppressing noise impulses received along with weak signals or with relatively strong signals.

Still another object of my invention is to provide an improved noise limiting circuit which automatically adjusts itself under all signal conditions to provide highly effective limiting action with a minimum of distortion of the desired signal.

Still another object of my invention is to provide an improved noise limiting circuit which effectively silences the receiving apparatus in response to a transient which exceeds a predetermined limiting level, this level being automatically controlled by the received signals themselves, and which provides rapid recovery of the receiving circuits to normal operation following such an impulse, under all conditions of operation.

It is still a further object of my invention to provide an improved noise limiting circuit which is simple, economical and readily incorporated in existing receiving 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 the circuits of a superheterodyne type of radio receiver, partly in

conventionalized form, which embodies my invention; and Figs. 2 through 4 are graphs which will be referred to for a better understanding of the operation of my invention.

In the superheterodyne receiving apparatus illustrated in Fig. 1, the signals received at the antenna 10 are amplified and converted into modulated carrier waves of intermediate high frequency in the radio frequency amplifier and converter 11. The construction and operation of these circuits are well known to those skilled in the art and hence they are indicated only schematically.

The intermediate frequency signals are next amplified. Two stages 12 and 13 of intermediate frequency amplification are illustrated, though of course there may be more or less than this number. For reasons that will shortly become apparent, it is desirable to give these intermediate frequency amplifiers a relatively wide band characteristic. This may be accomplished by various means familiar to those skilled in the art. Thus, in the illustrated embodiment, the coupling transformers 14, 15 and 16 are diagrammatically represented as being adjusted to the desired frequency by means of movable cores. Where the intermediate frequency is relatively high the windings of these transformers may be tuned by their distributed capacity alone, as is indicated in the drawing by the dotted capacities connected across the respective windings.

Operating potentials for the amplifiers 12 and 13 are supplied from a suitable power supply source, represented conventionally by the battery 20. The anodes of these amplifiers are connected to the positive terminal of the source 20. Their screen grids are connected to a point 21 on a bleeder resistor 17 shunted across this source. The cathode of the amplifier 12 is also returned to ground through a portion 19 of a second bleeder resistor 18, 19, the resistor 19 being variable for manual volume control purposes.

The amplified carrier waves of intermediate frequency, modulated by the audio signals, are impressed upon the second detector circuit 22 from the secondary winding 23 of the last intermediate frequency transformer 16. The signal detector 24 is of the diode type having an anode 25 and a cathode 26. The signal detector circuit extends from the anode 25, through the secondary winding 23 of the input transformer 16, a diode load resistor 27 and an intermediate frequency by-pass capacitor 28 in parallel, to the cathode 26, which is grounded.

The operation of the second detector circuit

22 is well known to those skilled in the art and will not be detailed here. The detector 24 is effective to demodulate the waves impressed upon the transformer 16. The demodulation products developed across the diode load resistor 27 include audio frequency components and a direct current component. The audio frequency components are coupled to the audio and power amplifiers, indicated schematically by the block 29, through a coupling capacitor 30. The amplified audio frequency currents appearing in the output of the amplifier 29 are supplied to any suitable translating device, such as the loud speaker 31.

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 form an undesirable noise background with the desired signal, or even mask it completely. 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, within this category are natural atmospheric static surges, man-made electrical disturbances, as from high frequency apparatus, ignition systems and the like, and other sharp impulses. The characteristics of these undesired noise pulses 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 signals 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. As is disclosed in my aforesaid application Serial No. 364,160, this network includes a second diode detector 40 reversely connected in parallel to the signal diode 24 through a capacitor 41. A discharge circuit, comprising resistors 42 and 43 in series, is also connected across the capacitor 41. For reasons that will shortly become more fully apparent, the time constant of the network 41, 42, 43, i. e., the product of the capacity and resistance of this network expressed in seconds, is made relatively long as compared to the time constant of the signal diode load network 27, 28. In other words, the time constant of the limiter network is made long as compared to the period of the lowest modulation signal frequency to be supplied to the amplifiers 29. The internal resistance of the diode 40 in the current-conducting direction should also be approximately equal to the internal resistance of the signal diode 24 for best results.

Considering for the moment only those elements of the noise limiting network just described, it will be observed that the diode 40 is in circuit with the secondary winding 23 and the network 27, 28 and that is poled to pass current through these elements, when conductive, in the opposite direction from current flowing in the signal diode circuit 22. This circuit extends from the anode 44 of the diode 40 through the network 41, 42, 43, the network 27, 28, and the secondary winding 23 of the transformer 16 to the cathode 45.

The signal diode 24 passes current on the peaks of those half cycles of the applied carrier wave which makes its anode positive, and the modulation voltages appearing on the network 27, 28 reproduce the modulation envelope. On the peaks of alternate half cycles, the maximum voltage

impressed across the diode 40 from the second detector 24 is approximately equal to the sum of the maximum diode load voltage on the network 27, 28, and the peak voltage of the applied carrier waves. These two voltages are approximately equal and hence the peak voltages applied across the diode 40 and network 41, 42, 43 are approximately equal to twice the peak amplitude of the carrier waves developed across the winding 23.

Due to the relatively long time constant of the network 41, 42, 43, the diode 40 functions as a peak rectifier on the outward peaks of audio modulation and charges the capacitor 41 up according to the peak values of the signal and modulation levels. The diode 40 therefore draws from the signal detector circuit 22 only the small current necessary to replenish the charge on the capacitor 41 as it leaks off through the resistors 42 and 43. The potential on capacitor 41 varies with the modulation envelope so that noise peaks can be limited substantially at the peak signal level, as will shortly appear. At zero modulation, or very low levels of modulation, limiting takes place approximately at the carrier level. The bias potential on diode 40 developed from peak rectification of the voltages across signal diode 24, thus may vary between approximately two and four times the unidirectional component of the carrier voltage developed on diode load resistor 27.

Assume now that an undesired noise impulse of greater magnitude than the received signal and of short duration is impressed on the secondary 23 of the transformer 16. 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 27 in both directions and capacitor 41 is of low impedance for impulses which are conducted by diode 40. Therefore, since no rectification of the noise transient takes place, it is effectively suppressed, producing substantially no effect upon the audio output circuits 29.

It may be noted at this point that the effectiveness of the noise suppression circuits is materially increased by employing wide band intermediate frequency circuits preceding the detector and limiter and relatively narrow band audio circuits following them. This fact becomes apparent from a study of impulse excitation characteristics of tuned circuits. In a wide band circuit the train of oscillations set up by a single short sharp impulse, has a very high decrement; whereas, in a narrow band circuit, the converse is true. In other words, the length of the decay train is inversely proportional to the acceptance band width of the system. On the other hand, it has been found that the peak amplitude of the train is almost directly proportional to the band width. Therefore, it can be shown that the average value of a given impulse train is practically independent of band width.

From the above principles, it follows that sharp noise impulses impressed on the wide band intermediate frequency amplifiers 12 and 13 remain sharp and of short duration in transmission through these circuits. If these impulses are now limited substantially to the peak carrier level in the manner previously described, very little energy remains. Then, if they are further filtered at the diode load 27, 28 and further reduced in peak amplitude by restriction in the relatively narrow band audio circuits 29, they are

actually reduced in amplitude far below the signal level.

It has been pointed out in my aforesaid application Serial No. 364,160 that the effectiveness of a noise suppression circuit of this general type, operating in the manner previously described, is greater on strong signals than on weak signals. The reason for this will become more fully apparent from a consideration of the curves of Fig. 2 in conjunction with the following description.

The upper curve in Fig. 2 represents the recovery characteristics of the noise limiting circuit under weak signal conditions. For illustration, it is assumed that a sharp noise transient exceeding a constant signal level 50 suddenly charges the capacitor 41 up to twice its previous value, as indicated by the peak 51. The condenser 41 now discharges back toward the signal level through the resistors 42 and 43 along the logarithmic curve determined by the time constant RC of the network. It will be seen that the actual recovery time is approximately represented by the time interval t_1 .

The lower curve in Fig. 2 represents the recovery characteristic of the same circuit when the noise transient exceeds the signal level by the same amount as before but where the signal level 52 is many times greater. The condenser now discharges from the peak 53 toward the signal level along a curve of the general form shown. Since the time constant RC is the same, it will be apparent that the time interval t_2 is materially shorter than t_1 .

The time required for the capacitor 41 to discharge back to the peak signal level determines both how much of the useful signal is suppressed and how quickly the noise limiting circuit is restored to normal. A quick recovery rate is particularly important on sustained impulse "noise" which tends to maintain capacitor 41 continuously charged, impairing the limiting action.

Consequently, it follows that the voltage on the capacitor 41, derived from peak rectification of the signal and carrier voltages, is a measure of the limiting effectiveness in the general form of circuit under consideration. Considered another way, the limiting action varies with the condenser discharge current in the resistors 42 and 43. It will be recalled that the capacitor voltage, and hence this current, varies both with the intensity of the received carrier signal and with its percent modulation. The discharge current will vary generally within limits, as indicated by the cross-hatched area between the curves 54 and 55 of Fig. 4, representing conditions of 100 per cent modulation and zero per cent modulation, respectively.

Summarizing, in the simplified form of limiter circuit considered up to this point, the noise limiting action is least effective on weak signals when it is most needed to preserve the intelligibility of the received signal. In order to alleviate these conditions, it has been shown in my application Serial No. 364,160 that improved limiting action on weak signals may be obtained by the addition of a source of potential in series with the discharge circuit for the capacitor 41. This source is poled to produce a small current flow, under no-signal conditions, through the noise diode 40. It is also pointed out in my aforesaid application that the addition of such a potential source increases the speed of recovery of the noise suppression circuit after a noise impulse, particularly for weak signal reception, since it

assists in discharging the capacitor 41. However, it is also pointed out that this improved limiting action is secured at some sacrifice of fidelity. Harmonic distortion in the desired signals is increased due to the additional load placed on the signal detector circuit. While such distortion can be tolerated in voice-communication work and in weak signal reception, where intelligibility is the primary objective, it may become objectionable when operating on strong signals.

Ideal noise limiting would be much more closely approached if the noise limiting circuits were fully automatic, so as to limit substantially to the peak signal level, and yet had a constant rate of recovery under all signal conditions. In accordance with my present invention, this is accomplished by applying a variable bias potential to the condenser discharge network and providing means for automatically varying this bias potential in response to the capacitor voltage so as to maintain the discharge current in the network substantially constant under all signal conditions.

In accordance with the present invention, a control circuit including a grid-controlled amplifying device 60 is incorporated in the noise limiting circuit. This device is represented in Fig. 1 as a triode having an anode 61, a grid 62 and a cathode 63. The grid 62 is connected to the junction point 64 between the capacitor 41, resistor 42 and anode 44. The cathode 63 is connected to the junction point 65 between the resistors 42 and 43. The anode 61 is connected to the lower end of the resistor 43 through a source of anode operating potential, represented by the battery 66. The anode voltage for the amplifier 60 may be adjusted by means of a movable tap 67. The grounded terminal of the capacitor 41 is connected to an intermediate point on the potential source 66 by means of a movable tap 68.

It will be seen that the resistor 42 is included in the grid circuit of amplifier 60 and the resistor 43 and potential source 66 in its anode circuit. For reasons that will shortly be apparent, the resistor 42 is of very high resistance as compared to the diode load resistor 27; whereas the resistor 43 is of the same order of magnitude as resistor 27. For example, in one particular embodiment of my invention, a value of 10 to 20 megohms for the resistor 42 and about 50,000 ohms for the resistor 43 were found to be satisfactory.

The operation and adjustment of the noise limiting and control circuits will be better understood from a consideration of the curves of Fig. 3 in conjunction with the following description. The manner in which the various voltages, indicated at E_1 , E_2 , E_3 and E_4 in Fig. 1, vary with the received signal intensity is represented by the several curves of Fig. 3 bearing corresponding symbols.

First assume that the grid 62 is at ground potential, that no signals are being received and that anode potential has just been applied to the control device 60. The device 60 now draws anode current through the resistor 43, producing the voltage drop E_2 , which is of opposite sign to the adjustable bias voltage E_3 between the lower end of resistor 43 and ground. Consequently, a net voltage equal to their algebraic sum is impressed between point 65 and ground. This voltage $E_2 + E_3$ is of such value that the cathode 63 has a positive potential with respect to ground under

no-signal conditions. This in turn causes a small current to flow through resistor 42, noise diode 40, transformer winding 23, and the diode load resistor 27 to ground. The grid 62 is biased approximately to "cut-off" by the voltage drop across resistor 42 and is held substantially at zero potential with respect to ground. Thus, a condition of equilibrium is reached practically instantaneously between the anode current in the amplifier 60 and the grid bias developed across the resistor 42.

Assume now that a signal is impressed upon the receiving apparatus. Signal voltages are now developed upon the signal detector 24. The capacitor 41 charges through the noise diode 40, due to the peak rectification action of the noise limiting circuit, as previously described. The voltage E_4 across the capacitor 41 now increases with increased carrier or modulation in a sense to render the point 64 more negative. As a result, the anode current in the control amplifier 60 tends to decrease, thereby causing the voltage E_2 to decrease. A new condition of equilibrium is now immediately established. Within the operating range of the control amplifier 60, its grid potential changes only negligibly. No grid current flows under any conditions.

It will thus be apparent from the foregoing and from an inspection of Fig. 3 that the voltage $E_2 + E_3$ at the cathode 63 instantaneously follows the voltage E_4 at the grid 62 so as to maintain a substantially constant difference between them (the voltage E_1) over a wide range of signal intensities. The voltage E_1 will remain substantially constant for all values of signal and noise impulse intensities up to the point where the magnitude of E_4 approximately equals the magnitude of $E_2 + E_3$ under no-signal conditions. The value of E_3 is adjusted to give the necessary range of operation for the noise limiting circuit under all operating conditions of the receiver. It may be zero under some conditions.

The value of E_1 is determined by the voltage applied to the anode 61 and is approximately equal to the anode voltage divided by the amplification factor of the tube 60. It may be adjusted by moving the tap 67.

It will also be observed that the voltage E_4 at the point 64 can never become positive with respect to ground because resistor 42 is of very high resistance as compared to resistor 27 and diode 40 becomes conducting whenever its anode 44 is rendered positive.

If E_1 has a constant value, as shown in Fig. 3, then the discharge current through the resistors 42 and 43 will also be substantially constant, since resistor 42 is very much larger than resistor 43, as previously described. The curve 70 in Fig. 4 represents the discharge current under these conditions. It will be observed that it is substantially constant over a wide range of signal intensities and that it is independent of the percent modulation of the received carrier wave.

The rate of recovery for the RC network 41, 42, 43 is now substantially constant under all signal conditions. Therefore, as the signal level increases, the ratio of discharge current drawn by the limiter network to the signal current flowing in the signal detector circuit 22 decreases, reducing harmonic distortion in the audio signal to an extremely low level. At the same time, the limiting action is highly effective under weak signal conditions.

Merely for the purposes of illustration, the following data is given for a particular radio receiv-

ing apparatus embodying my invention. These values were found to give satisfactory results in a particular case although they are not to be regarded as necessarily applicable to all embodiments of my invention.

Band width of I. F. amplifiers	About 300 k. c.
Band width of audio amplifiers	About 5-10 k. c.
Capacitor 41	.01-.1 mfd.
Resistor 42	10-20 megohms.
Resistor 43	About 50,000 ohms.
Voltage E_3	30 volts.
Control amplifier 60: Type 6J5, anode voltage on amplifier 60	150-300 volts.

A type 6J5 amplifier was used for the control tube in this particular application because it is a general purpose tube of suitable amplification factor. With one adjustment of this particular apparatus, the voltage drop E_2 upon the resistor 43 under no-signal conditions was about 46 volts. Hence, the cathode 63 was at about plus 16 volts above ground and the grid 62 at about ground potential. Under strong signal or noise conditions the grid 62 and the cathode 63 decreased together so as to maintain substantially 16 volts bias on the grid 62 at all times until the cathode potential reached a maximum of about minus 30 volts, corresponding to minus 46 volts on the grid 62 with respect to ground.

It will of course be apparent to those skilled in the art that many modifications within the scope of my invention may be made. For example, in some cases it may be desirable to include an additional capacitor, connected between the cathode 63 and ground, of a suitable size to assist in the recovery of the noise limiting circuit after a very strong noise transient. Such a capacitor will permit the voltage E_1 , and therefore the discharge current, to increase momentarily in proportion to the charge effect of a noise transient, but only during the recovery time of the noise limiting network.

Other modifications will doubtless occur to those skilled in the art. Hence, while I have shown a particular embodiment of my invention, it will be understood that I do not wish to be limited thereto, but I contemplate by the appended claims to cover any 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 a radio receiving system, a signal channel normally operative for the translation of signal voltages, signal-responsive means for establishing a threshold limiting level controlled by said voltages and for disabling said channel in response to a transient noise impulse exceeding said level, said means tending to restore said channel toward operative condition following said impulse at a time rate dependent upon the instantaneous magnitude of said level, and means responsive to the instantaneous magnitude of said threshold level for maintaining said time rate substantially constant irrespective of said level.

2. In a radio receiving system, a signal channel normally operative for the translation of signal voltages, means for charging a capacitor to a threshold limiting level determined by said voltages, means for disabling said channel in response to a transient noise impulse which increases the voltage on said capacitor above said level, means comprising a discharge circuit for

discharging said capacitor back to said level following said impulse, thereby to restore said channel to operative condition, and means responsive to the voltage on said capacitor for maintaining a substantially constant current in said discharge circuit over a wide range of voltage variations on said capacitor.

3. 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 including an input impedance, a signal rectifier and an output resistor connected in series, said resistor being bypassed for carrier frequencies, a noise suppression diode having an anode and cathode reversely connected across said signal rectifier through a capacitance element, a resistance element connected in shunt to said capacitance element through a source of variable bias potentials, said elements having a relatively long time constant and said source being poled to bias said anode positively in the absence of said carrier waves, and means responsive to voltages on said capacitance element for varying said bias potentials.

4. In combination with a source of potentials subject to undesired transients, a capacitance, means responsive to said potentials for charging said capacitance, means for discharging said capacitance comprising a resistance in circuit therewith, and means responsive to the voltages on said capacitance for maintaining a substantially constant voltage across said resistance over a predetermined range of voltage variations on said capacitance, thereby to maintain a substantially constant discharge current from said capacitance over said range.

5. In combination with a source of signal-modulated high frequency carrier 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 capacitor, said devices being poled to pass current through said output impedance in opposite directions when conductive, means coupled to said source for impressing said carrier potentials on both of said circuits, means comprising said second device and capacitor for effecting peak rectification of the carrier and signal potentials impressed on said second device, thereby to bias said anode negatively with respect to said cathode, said second device having a low impedance for noise impulses which overcome said bias, whereby said impulses tend to charge said capacitor through said second device, means for discharging said capacitor comprising a resistance in circuit therewith, and means responsive to the voltages on said capacitor for maintaining a substantially constant voltage across said resistance over a predetermined range of voltage variations on said capacitor.

6. In a system for translating signal potentials subject to undesired noise transients, a capacitance, means responsive to said potentials for charging said capacitance, means for discharging said capacitance comprising a resistance connected in circuit therewith, means for impressing a bias potential across said capacitance and resistance in a polarity to assist in discharging said capacitor, and means responsive to the voltages

on said capacitance for varying said bias potential.

7. In a system for translating carrier waves modulated by a band of signal frequency waves and subject to undesired noise transients, a capacitance element, means responsive to said waves for charging said element in one polarity, means for discharging said element comprising a resistance element in circuit therewith, said elements having a time constant long as compared to the period of the lowest signal frequency, means for impressing a bias potential across said elements in a polarity to assist in discharging said capacitance element and to maintain a current flow through said resistance element and charging means, and means responsive to the voltages on said capacitance element for varying said bias potential so as to maintain said current flow substantially constant over a wide range of voltages on said capacitance element.

8. In combination with means for receiving signal-modulated potentials subject to interfering noise transients, a signal detection circuit coupled to said means including a first unilaterally conducting discharge device, a noise suppression circuit coupled to said means serially including a second, reversely connected, unilaterally conducting discharge device and a capacitance, a discharge circuit for said capacitance comprising a resistance and a source of variable bias voltage, said source being poled to maintain a current flow through said second device and resistance, and means responsive to voltages developed across said capacitance through rectification of potentials impressed on said noise suppression circuit for varying said bias voltage so as to maintain a substantially constant current flow through said resistance over a wide range of voltage variations on said capacitance.

9. In combination with means for receiving carrier waves modulated by a band of signal frequency waves and subject to undesired transients, a signal detection circuit coupled to said means serially including a signal diode and an output load impedance, a noise detection circuit comprising a noise diode reversely connected across said signal diode through a capacitance element, a discharge circuit for said element comprising a resistance element in series with a source of variable bias voltage, said source being poled to maintain a current flow through said resistance element and noise diode, said elements having a time constant long as compared to the period of the lowest signal frequency, whereby said noise diode develops potentials across said elements by peak detection of the waves appearing across said signal diode, and means responsive to said potentials for varying said bias to maintain said current flow substantially constant over a wide range of potential variations on said capacitance element.

10. 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 including an input impedance, a signal rectifier and an output resistor connected in series, said resistor being bypassed for carrier frequencies, a noise suppression diode having an anode and cathode reversely connected across said signal diode through a capacitance element, a resistance element connected in shunt to said capacitance element through means supplying variable bias potentials, said elements hav-

ing a relatively long time constant and said bias potential means being poled to bias said anode positively in the absence of said carrier waves, and means responsive to voltages on said capacitor for varying said bias potentials.

11. In combination with a source of signal potentials subject to undesired transients, a capacitance, means responsive to said potentials for charging said capacitance, means for discharging said capacitance comprising a resistance in circuit therewith, means for impressing bias potentials on said resistance to maintain a predetermined current therethrough in absence of said signal potentials, said means including an impedance in the anode circuit of a grid-controlled amplifying device, and means responsive to the voltages on said capacitance to maintain said current substantially constant over a wide range of voltage variations on said capacitance, said last means comprising connections for impressing voltages on said resistance upon the grid of said device.

12. In apparatus for receiving carrier waves modulated by signal frequencies and subject to interfering noise transients, a signal detection circuit serially comprising an input impedance, a signal diode and an output impedance, a noise suppression diode reversely connected across said signal diode through a capacitor, a discharge network connected in circuit with said capacitor comprising a resistance having two sections, a thermionic amplifier having grid and anode circuits, said grid circuit including one section of said resistance and said anode circuit including a source of anode operating potential and the other section of said resistance, said anode circuit being connected in such polarity that flow of anode current produces a bias potential across said other section tending to maintain said noise diode conductive.

13. In apparatus for receiving carrier waves modulated by signal frequencies and subject to interfering noise transients, a signal detection circuit serially comprising an input impedance, a signal diode and an output impedance network of suitable time constant for detection of said signals, a noise suppression diode reversely connected across said signal diode through a capacitor, a discharge network connected across said capacitor comprising first and second resistances in series, the time constant of said capacitor and discharge network being long relative to that of said output impedance network, a thermionic device having an anode, a cathode and a grid,

said grid being conductively connected to the outer extremity of said first resistance, said cathode being conductively connected to the junction of said resistances and said anode being conductively connected to the outer extremity of said second resistance through a source of anode operating potential, the direction of anode current flow through said device and said second resistance being such that the voltage drop thereby produced across said second resistance tends to maintain said noise diode conductive.

14. In apparatus for receiving carrier waves modulated by signal frequencies and subject to interfering noise transients, a signal detection circuit serially comprising an input impedance, a signal diode and an output impedance network of suitable time constant for detection of said signals, a noise suppression diode reversely connected across said signal diode through a capacitance, a discharge network connected across said capacitance comprising a resistance and a source of bias potential, said potential tending to render said noise diode non-conductive, said resistance having relatively high value and said resistance and capacitance having a relatively long time constant as compared to said output impedance network, a thermionic device having grid and anode circuits, said grid circuit including a major portion of said resistance and said anode circuit including a source of operating potential and the remaining portion of said resistance, said anode circuit being so connected that flow of anode current through said remaining portion produces a voltage drop thereacross opposing said bias potential, and means for adjusting said potentials to maintain a predetermined current flow through said resistance and noise diode.

15. In a radio receiving system, a signal channel normally operative for the translation of signal waves, an energy storage device, means for establishing a threshold limiting potential level across said device controlled by said waves and varying as a function thereof, means for increasing the voltage across said device momentarily in response to a transient noise impulse exceeding said level and for disabling said channel so long as said voltage exceeds said level, and means responsive to the instantaneous magnitude of said threshold level for causing said voltage to decrease upon cessation of said impulse toward said level at a substantially constant time rate irrespective of the value of said level, thereby to restore said channel to operative condition.

GEORGE W. FYLER.