Aug. 10, 1948. C. WASMANSDORFF 2,446,565

RADIO RECEIVER NOISE REDUCING CIRCUIT

Filed Sept. 29, 1942 2 Sheets-Sheet 1

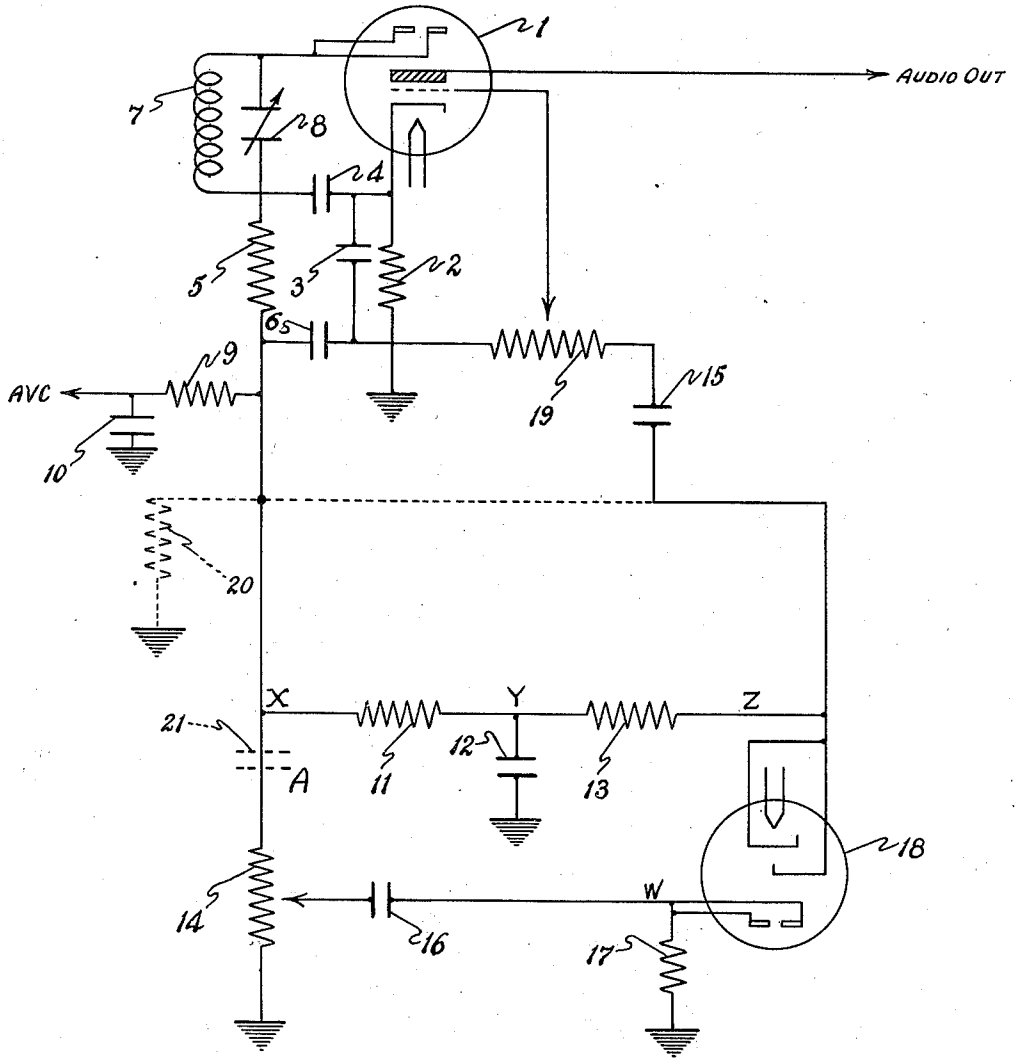


Figure - 1.

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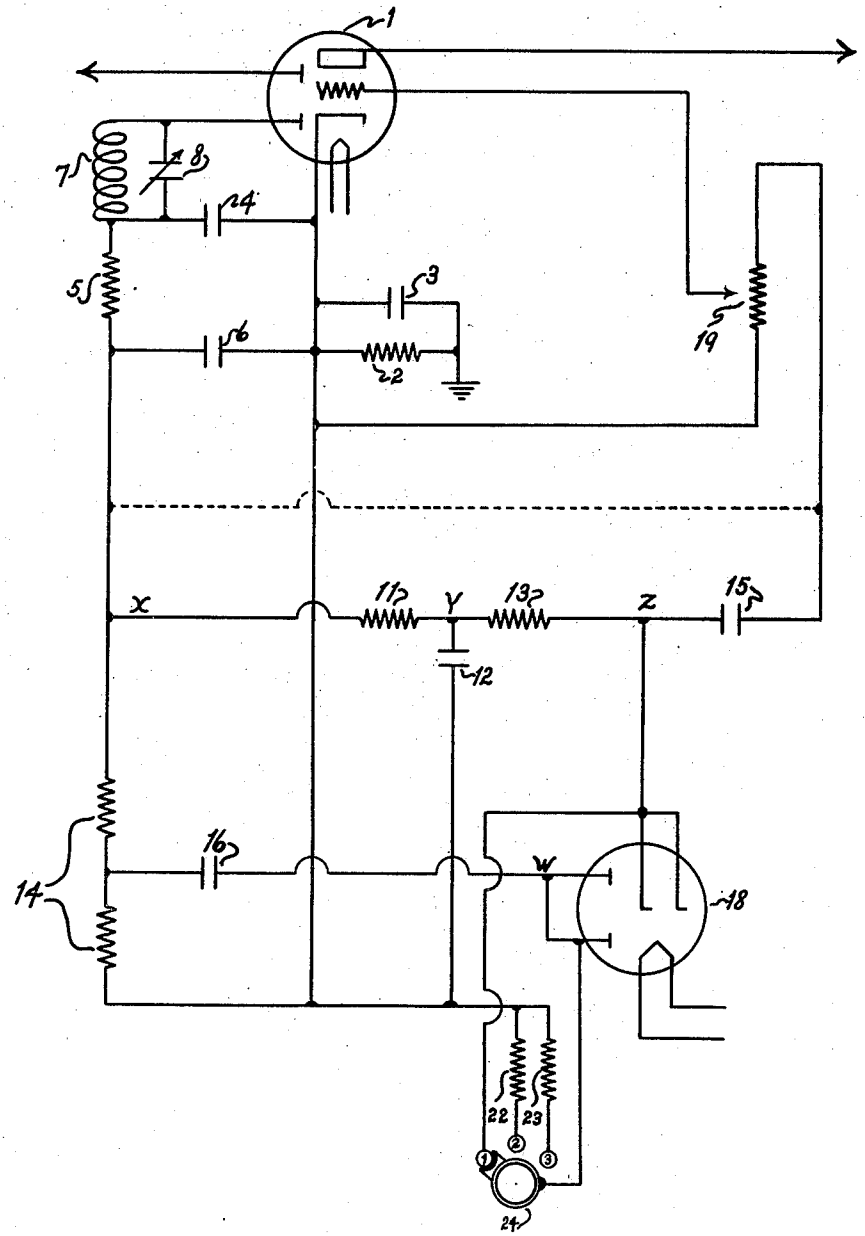


Figure-2.

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RADIO RECEIVER NOISE REDUCING CIRCUIT

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9 Claims. (Cl. 250—20)

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The primary object of my invention is to automatically reduce extraneous noise in radio receivers, particularly those operating on ultra high frequencies.

A further object resides in the provision of a device particularly adapted to avoid circuit complexity or the necessity for adjustment to accommodate signals of various strengths.

A further object of the invention is to provide a device which limits the magnitudes of all demodulated voltages to a maximum peak value which is determined by reference to the average strength of the received signal as it reaches the portion of the receiver where demodulation takes place.

Still another object is the provision of a device of this character in which the peak limiting value may be readily adjusted to a value corresponding to a desired degree of modulation of the received carrier. It is a feature of the invention that this adjustment may be made over a relatively wide range of values without adversely disturbing other operating conditions within the circuit.

A further object of the invention consists in the provision of a circuit which will discriminate against transient disturbances such as short bursts of static, by retaining the peak limiting action relatively unaffected by such bursts. The peak limiting action, however, remains at all times subject to control by the average strength of the received carrier and limits the peaks which may be passed to values corresponding to the predetermined percentage of modulation of the incoming carrier referred to above.

Another object of the invention is to provide a noise reducing circuit which is capable of adjustment to limit the peak values of demodulated signal which will be passed by the circuit so that they will not exceed those which occur with some adjustably selected degree of carrier modulation less than 100% modulation, such as 40% modulation, for example. The reason for so adjusting the device to limit at peak values below those which accompany full modulation of the carrier is that the intelligibility is impaired to a greater degree by the larger peak values of noise than by the distortion produced by limiting the peaks of the demodulated signal to a maximum value less than that of the peaks which accompany full modulation. Listening tests conducted under heavy noise conditions have definitely indicated that under such circumstances it is desirable to limit all demodulated peak voltages to values which are considerably lower than the maximum signal peaks produced by full modulation of the carrier.

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The circuit of the present invention reduces noise during the reception of signals to a maximum value commensurate with the strength of the received signal, and has a further inherent advantage, namely, when the receiving apparatus is left in operation but when no carrier or an extremely weak carrier is being received the operator will receive substantially no output whatever from the circuit.

The noise reducing circuit of the present invention comprises means for generating a unidirectional control current or voltage, the magnitude of which is continuously dependent upon the average amplitude of the received carrier appearing at the detector input. This unidirectional voltage is applied to a rectifier, such as a thermionic vacuum tube, in its conducting direction with the resulting flow through the rectifier of an irreversible current whose magnitude continuously follows the average amplitude of the carrier wave to be demodulated. The signal modulations of the carrier are applied to the circuit carrying the irreversible undirectional current and are applied thereto with such phasing that they tend to reduce this current to zero but are prevented by the rectifier from reversing this current. The limiting action results from their inability to reverse the unidirectional current.

The circuits through which the signal modulations are applied are independent of the direct current circuits and adjusting means are provided which permit the degree of modulation at which limiting occurs to be varied without materially affecting the direct current potentials in the apparatus. This arrangement gives improved flexibility of adjustment not found in earlier devices of this character.

Other objects and advantages of the invention will more fully appear as this specification proceeds and are set forth in the appended claims.

I attain these objects by the device described in the accompanying drawing, in which Figure 1 is a diagrammatic view, showing an embodiment of the invention applied to a typical superheterodyne receiver. That portion of the receiver circuit diagram is shown which includes the secondary of the last intermediate frequency transformer, a diode second detector, triode first audio amplifier, and those components comprising the noise reducing circuit. This is, by way of example only, as it should be understood that the noise reducing circuit may readily be installed in any superheterodyne or tuned radio frequency receiver, the exact schematic and circuit values depending upon the original design of the receiver.

Figure 2 is a diagrammatic view of the device in a modified form as is hereafter more fully explained.

My noise reducing circuit is adaptable to any standard receiver of either the superheterodyne or tuned radio frequency type. Its installation has no effect on the operation of the receiver other than that for which the circuit is intended.

Similar numerals and letters of reference refer to like parts throughout the drawing, thus 1 indicates a combined diode second detector, triode first audio tube as commonly used in many receivers. 2 and 3 comprise the usual cathode biasing resistor, by-pass condenser combination for the triode portion of tube 1. 4 designates the intermediate frequency by-pass condenser, and this condenser may be connected to the cathode or to ground depending upon the design of the receiver. 5 and 6 designate parts of the intermediate frequency filter and may or may not be used, this also depending upon the design of the receiver. 7 designates the secondary of the last intermediate frequency transformer and 8 designates the tuning condenser for the secondary of the last intermediate frequency transformer. 9 and 10 represent the usual automatic volume control filter system. The automatic volume control voltage may be taken from the point shown, or at any other point on the diode load resistor, or from a separate source according to the design of the receiver. The point from which the automatic volume control voltage is taken is not pertinent to the operation of the invention. 19 designates the volume control resistor as commonly used. 20 designates the diode load resistor which has been removed from the circuit upon installation of the invention, the dotted line showing its former connection to the diode return load and volume control 19 through the blocking condenser 15. That portion of the circuit diagram lying below the dotted line in the diagram comprises the noise reducing circuit which has been added.

In order to obtain a clear understanding of the basic operation of the circuit, we may assume, for example, that an amplitude modulated carrier is received. Then, at point X, there will exist a negative D. C. voltage, produced by the diode portion of tube 1, the value of which will be dependent upon the average value of the rectified intermediate frequency wave. Superimposed thereon is an audio frequency wave whose shape is that of the signal modulation, and whose peak value is dependent upon both the modulation percentage and carrier strength of the received wave. This point is where the demodulated signal output is usually taken through a blocking condenser 15 which feeds the volume control 19 and the grid of the triode amplifier. This is shown by the dotted line which indicates removal of this connection.

In installing the present noise reducing circuit, the superimposed signal modulations are removed from the D. C. voltage by the low-pass signal frequency blocking filter 11 and 12. There is left at point Y a relatively steady negative D. C. voltage whose value is principally dependent upon the average strength of the carrier frequency of the received signal.

If then, a relatively large amount of noise is received, at point X there will be a negative D. C. voltage as aforementioned, and whose value is dependent upon the average value of the rectified intermediate frequency wave. Superimposed upon this D. C. voltage will be another voltage whose peak value is dependent upon the received noise. This latter voltage is similarly removed by the filter 11 and 12 leaving at point Y a negative D. C. voltage whose value is dependent upon the combined average strength of the signal and the noise. The D. C. voltage generated when noise only is being received will ordinarily be small compared with the D. C. voltage generated when a carrier is being received by the circuit, and this is true even though noise currents having large peak values are being received.

There is a further effect present in that when noise alone is being received there is a time lag in the rise of the D. C. voltage at the point Y dependent upon the time constant of the filter 11 and 12, so that the rise in D. C. voltage at the point Y will not occur in such phase as to be effective for permitting the passage of noise through the apparatus, as hereinafter pointed out.

The low-pass signal frequency blocking filter 11 and 12 may consist of an inductive reactance not shown and a capacitance instead of resistance and capacitance as shown. Resistors 13 and 17 also may be replaced by inductive reactances not shown.

The filtered unidirectional voltage at point Y is used to produce a corresponding residual or control current flowing through diode 18. The circuit of diode 18 includes a load resistor 13 which may be replaced by an inductor if desired. It will be noted that this negative potential is applied in the conductive direction to diode 18 and that as a result of the unidirectionally conductive characteristics of diode 18, the current in this portion of the circuit cannot be reversed to any appreciable extent.

Since the voltage at point Y is negative with the particular receiver shown, the voltage is applied through the load to the cathode of the diode 18. The plate is connected to resistance 17 or reactance not shown and thence to ground for the return circuit.

The audio voltage component developed across the load resistor 14 is taken through a blocking condenser 16. This condenser may be located as shown at 21, point A, in which case the resistor 14 may or may not be used depending upon the design of the particular receiver.

The audio component through 16 is then applied to the diode 18 at point W across load 17. The magnitude of the audio voltage component applied to the plate of the diode 18 will depend upon the point on resistor 14 from which the signal is taken. Thus the proper ratio signal voltage to control current producing voltage is obtained. The D. C. current flowing from point Y through the parts 13, 18, and 17 to ground is then increased or decreased in accordance with the audio voltage at point W, thereby producing an audio voltage of similar wave shape across the points Y and Z, however, the peak value of this audio voltage has been limited by the D. C. voltage available at point Y and the unidirectionally conducting characteristics of diode 18. It is this developed voltage between points Y and Z that is used to feed the signal frequencies to the input of the amplifier through blocking condenser 15.

The circuit of the present invention operates as follows in reducing noise:

Considering, first, the case where the circuit is receiving a modulated carrier, which modulated carrier contains in addition to the modulated signal which it is desired to receive, noise peaks having a magnitude in excess of the mag-

nitude of the desired signal. The desired signal on the modulated carrier may be either sound frequencies, higher frequencies or frequencies derived from a local beat oscillator where continuous wave telegraph signals are being received. In such case, one-half of the modulating envelope of the modulated carrier is cut off by the rectifying action of the diode portion of tube 1. The output of this diode portion of tube 1 (after passing the intermediate frequency filter 5—6) therefore consists of a steady unidirectional component, the magnitude of which is substantially dependent on the average magnitude or the unmodulated magnitude of the carrier at tuned circuit 7, 8. The output also includes unidirectional signal frequency components impressed on the steady unidirectional component together with noise peaks. The noise peaks, however, mainly represent distortions of the signal frequencies on one side of the signal, the other side of the noise peaks having been cut off in the diode portion of tube 1.

A signal frequency circuit may be traced to include both the diode portion of tube 1 and the diode 18, such for example, as the circuit of the cathode of tube 1 to the plate of the diode portion through inductance 7, resistance 5, the adjustable tap on load resistance 14, condenser 16, the plate of rectifier 18, the cathode of rectifier 18, the condenser 15, load resistance 19, and cathode resistor 2 of tube 1, it will be seen that the diode portion of tube 1 and the diode 18 are opposite in phase; that is, the circuit leads from the cathode to the plate of the rectifier of tube 1 and, on the contrary, the circuit passes in order from the plate to the cathode of the rectifier 18. Accordingly, any increase in the current flowing from the cathode to the plate in the diode portion of tube 1 must tend to produce a decrease in the magnitude of current flowing through tube 18. Such decrease in current can occur in tube 18 only if the tube is carrying a current, and this current must flow in the tube in its conducting direction. Moreover, the current can decrease in tube 18 only to zero, but cannot be reversed. When this residual steady currient is adjusted, as by the circuit described, to a value corresponding to the average magnitude or unmodulated magnitude of the carrier, any received noise peaks passed by the rectifier 1 are cut off by their inability to reverse the direction of current flow in rectifier 18.

Now, consider the case if the circuit is operating with little or no incoming carrier. In this situation, no appreciable steady residual current will flow through the rectifier 18, except such as represents an average of the rectified noise components in the output of the diode portion of tube 1, which in turn produces a very small residual current compared with the amount of residual or control current which is obtained when the apparatus is receiving a carrier to be demodulated. Accordingly, the diode 18 passes a residual or control current which will limit the signal amplitudes to small magnitudes, the result being that whenever a carrier is not being received there is substantially no signal frequency output from the receiver.

The combined diode-triode tube 1 is shown with a common cathode connection for both the diode section and triode section of the tube. This has the effect of providing a minimum carrier level which must be received before any demodulation will take place. This condition arises because the common cathode is maintained at a

potential positive with respect to ground by cathode resistor 2 as a convenient means of providing grid bias for the triode section of the tube. This effect, if not desired, may be eliminated by the use of separate cathodes for the diode and triode sections, or by grounding the common cathode and supplying a suitable negative bias to the grid of the triode portion of the tube in a convenient part of the grid return circuit in conventional manner.

In the modification, Figure 2, a three-position switch 24 is introduced into the circuit whereby resistors 22 and 23 are controlled. The primary purpose of said control is to regulate noise reducing action of the system whereby a contact on switch point 1 completely suspends operation of the noise reducing circuit; a contact on switch point 2, on the other hand, retains the system in its full operative function, without voice distortion, in conjunction with resistor 22, while contact with switch point 3, connecting with resistor 23 operates to resist extremely high noise impulses for the reception of weak signals especially during C. W. reception; and also under conditions where transmitters are operated in close proximity to the receiver. As a suitable substitute for said switch, a rheostat may be connected in the circuit for the accomplishment of like objectives.

The tube 18 which is shown as a diode, may be replaced by a triode, tetrode, pentode, or other vacuum tube, or unidirectionally conducting device such as a copper oxide rectifier. If a triode, tetrode, or pentode is used, the plate may be grounded and the signal frequencies at point W applied to the grid or grids, the signal frequencies being taken at a proper voltage level to stop the flow through the tube at the desired peak limiting value.

Once installed, no adjustment is at any time required. The circuit is automatic in operation. Varying noise intensity, fading carrier, or no carrier, changes in R. F. gain of the receiver or any combination thereof have no adverse effect, and they do not change the characteristics of the device.

On radiotelegraph reception the key clicks are removed, yet the keying characteristic of the signal is retained. The device does not block for a period of time following the passage of a strong noise pulse or click. Nor does the beat oscillator used for telegraph reception block the device. Audio loss with the device installed on both radiotelephone and radio telegraph reception is less than when equipped with other devices in common use.

Moreover, because of the wave shape discriminating characteristics, even noises due to thermal agitation in the antenna and input circuits, and shot effect in the receiver are considerably reduced. Receiver sensitivity nevertheless remains unchanged.

The device may readily be produced from materials and equipment the open market affords, and at no great cost. It provides a smoothly operating electric circuit requiring little attention, is readily installable in most existing radio sets, as well as sets likely to be produced in the future, and at all times and under all conditions, if the set will operate at all, the circuit will render maximum performance in the practical elimination of noise.

I am aware that changes in construction of the device may from time to time readily suggest themselves, but within the scope herein set forth. Hence I do not limit my present invention to

the exact description of structure herein disclosed, but what I do claim is:

1. In a circuit for demodulating amplitude-modulated carrier frequency currents, limiting means for reducing noise by suppressing disturbances whose peak values exceed by a predetermined ratio the average value of the carrier current to be demodulated, comprising in combination; a demodulator of the rectifying type disposed to produce a uni-directional output comprising demodulated signal components and a direct current component, filter means connected to the output of the demodulator for deriving from the direct current component thereof a control voltage substantially free from signal components and substantially directly proportional in magnitude to the average magnitude of the signal to be demodulated, rectifier means capable of preventing appreciable current flow therethrough in its reverse direction and connected to be energized in its conducting direction by the control voltage, coupling means of the direct current blocking type coupled to the demodulator output for applying a predetermined portion of the demodulated signal components to the circuit of the rectifier means to control the instantaneous magnitude of control current flowing therethrough the phasing of the coupling being such that peaks of uni-directional demodulator output tend to reduce the control current to zero, and means coupled to the circuit of the rectifier means for deriving a signal output therefrom.

2. A circuit as in claim 1 in which the coupling means of the direct current blocking type is adjustable.

3. In a carrier frequency receiver comprising a detector followed by an audio-frequency amplifier, noise reducing means connected intermediate the detector and audio-frequency amplifier thereof comprising rectifying means, a first filtering means connected to said rectifying means for deriving a control voltage substantially directly proportional in magnitude to the average magnitude of the received carrier, direct current blocking means coupled to said rectifying means for modulating the current produced by said control voltage with the audio-frequency components of the output of the half-wave rectifying means, a second rectifying means connected to prevent reversal of the current flowing in the circuit of the control voltage by audio components instantaneously exceeding the magnitude thereof, and means for applying the control voltage thus modulated to the input of the audio-frequency amplifier.

4. A device for reducing noise appearing in the output of a radio or other high frequency receiver, said receiver comprising an audio frequency amplifier, said device being of the type in which noise reduction is effected by limiting any peak of voltage appearing at the input of the amplifier to a maximum value of predetermined ratio with respect to the average voltage value of the signal to be demodulated and amplified, comprising in combination; rectifier and filter means coupled to the output of that portion of the receiver immediately preceding the audio frequency amplifier portion thereof for deriving a control voltage substantially free from audio frequency components and substantially directly proportional in magnitude to the average voltage of the signal to be demodulated, a second rectifier, means for applying the control voltage to the second rectifier in its conducting direction to obtain a flow of current therethrough, means for demodulating the received signal coupled to the same portion of the receiver circuit as the rectifier and filter means, coupling means of the direct current blocking type for applying a predetermined proportion of the audio frequency components of the demodulated signal to the circuit of the second rectifier to control the instantaneous value of current flow therethrough in such phase relationship that peaks of voltage equaling or exceeding a predetermined magnitude in the output of the demodulating means will reduce the current flowing in the second rectifier to zero but not appreciably beyond, and means coupling the input of the amplifier to the circuit of the second rectifier to derive an audio frequency signal therefrom subject to the limiting action of the second rectifier.

5. A device for reducing the noise in the output of a radio or other high frequency receiver utilizing a final detector of the rectifying type comprising in combination; filter means coupled to the detector output to remove the high frequency components therefrom thus to produce a uni-directionally biased audio-frequency current, additional filter means for removing the audio-frequency components from the biased audio-frequency current to produce a uni-directional control current whose magnitude will be substantially directly proportional to the average signal intensity, a rectifier connected to be energized in its conductive direction by the filtered control current thus preventing reversal thereof, direct current blocking means for applying the audio frequency components of the first named current to the circuit of the rectifier to vary the instantaneous magnitude of the direct current flowing therethrough, the alternating components being applied with such polarity that increase in audio-frequency voltage tends to decrease the current flow through the rectifier in such a manner that peaks of detected voltage equaling or exceeding the value of the control current will reduce the rectifier current to zero, and means for amplifying and reproducing the audio frequency components thus limited of the current flowing in the rectifier.

6. The method of reducing noise appearing at the output of a device for receiving signals consisting of amplitude-modulated carrier frequency currents which consists in receiving and uni-directionally demodulating the received carrier frequency currents, filtering a portion of the demodulated currents to substantially remove all components of the signal frequencies therefrom and to produce a unidirectional control current whose magnitude is substantially directly proportional to the average magnitude of the carrier frequency current at the point of demodulation, preventing appreciable reversal of the control current, taking another portion of the demodulated currents and separating the signal frequency components therefrom, modulating the control current with the signal frequency components in such phase relationship that signal peaks tend to reduce or reverse the flow of control current thereby limiting the magnitude of such peaks, and deriving the output of the device from the control current thus modulated.

7. The method of reducing noise appearing at the output of a device for receiving signals in the form of amplitude-modulated carrier frequency currents which consists in receiving and uni-directionally demodulating the received carrier frequency currents, filtering a portion of the demodulated currents to substantially remove all

components of the signal frequencies therefrom and to produce a unidirectional control current whose magnitude is substantially directly proportional to the average magnitude of the carrier frequency current at the point of demodulation, checking appreciable reversal of the control current, taking another portion of the demodulated currents and separating the signal components therefrom, varying the instantaneous value of the control current by means of the signal components in such phase relationship that signal peaks tend to reduce or reverse the flow of control current thereby limiting the magnitude of such peaks, and deriving the output of the receiver from the control current thus modulated.

8. The method of reducing noise appearing at the output of a demodulator for carrier-frequency signaling currents which consists in uni-directionally demodulating the carrier-frequency currents, filtering a portion of the demodulated signals to substantially remove all components of the signal frequencies therefrom and to produce a unidirectional control current whose magnitude is substantially directly proportional to the average amplitude of the signal at the point of demodulation, preventing appreciable reversal of the control current, taking another portion of the demodulated signals and separating the signal components therefrom, modulating the control current with the signal components in such phase relationship that signal peaks tend to oppose and to reverse the flow of control current thereby limiting the magnitude of such peaks, and deriving the output of the demodulator from the control current thus modulated.

9. In a circuit for demodulating amplitude modulated carrier frequency signals, a diode detector connected to produce a unidirectional modulated current, a first low-pass filter connected in the detector output circuit for removing the carrier frequency components, a second flow-pass filter connected to the output of the first filter for removing the signal components to produce a direct current whose value is substantially proportional to the average amplitude of the carrier frequency signal to be demodulated, a second diode connected to prevent reversal of the direct current so produced, a potentiometer connected to the output of the first filter for deriving from the output thereof a predetermined portion of the unidirectional current modulated at signal frequencies, a high-pass filter connected to the output of the potentiometer for removing direct current components therefrom, means connected to apply the output of the high-pass filter to control the instantaneous value of the direct current flowing in the circuit of the second diode in such manner that unidirectional peaks of signal frequency passed by the first low-pass filter will tend to reduce the instantaneous value of current flowing in the circuit of the second diode to zero, and amplifier means connected to amplify the resulting current flowing in the circuit of the second diode to derive a demodulated signal output therefrom, whereby peaks of noise appearing in the signal output will be limited to magnitudes which cannot exceed a value which will reduce the second diode current to zero this limiting magnitude being substantially directly proportional to the average strength of the received signal.

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