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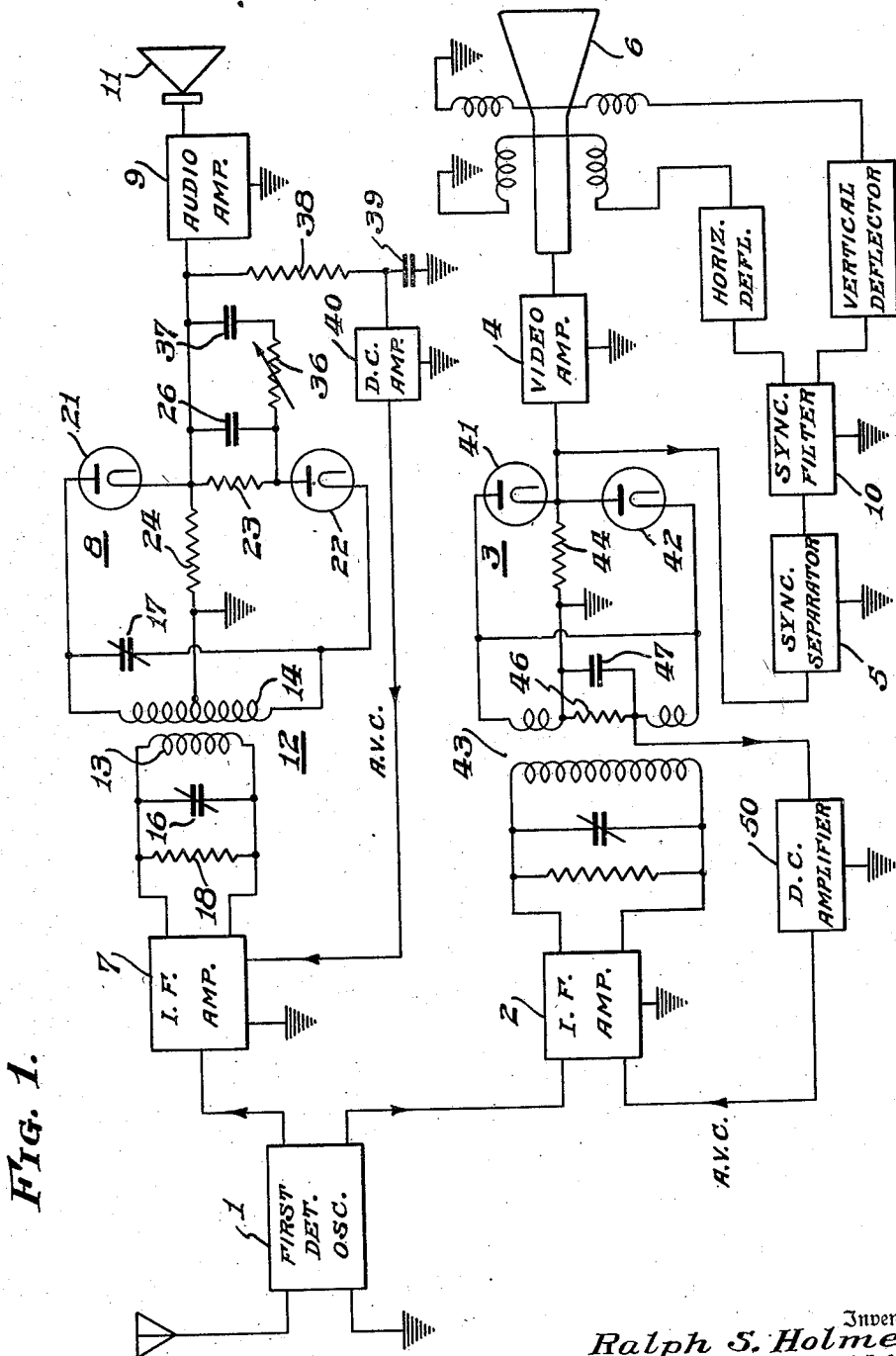
R. S. HOLMES ET AL

2,299,390

NOISE SUPPRESSOR

Filed Oct. 12, 1939

2 Sheets-Sheet 1



Inventors
*Ralph S. Holmes,
Ciro C. Martinelli*
BY *J. J. Huff* Attorney

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2 Sheets-Sheet 2

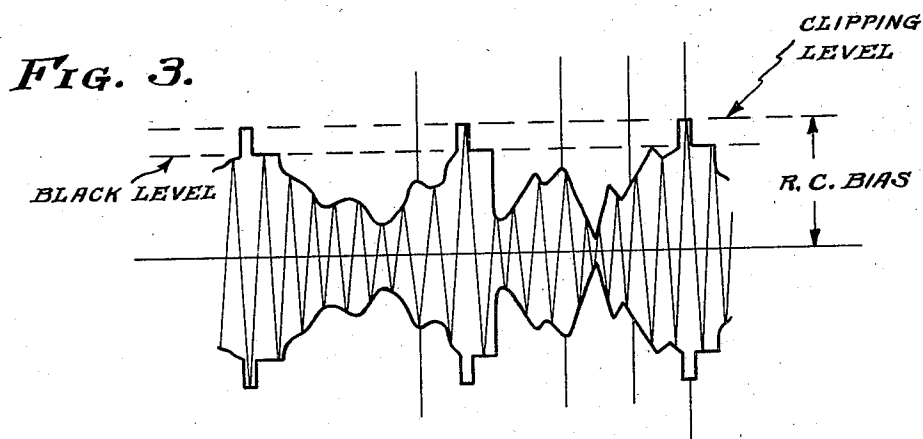
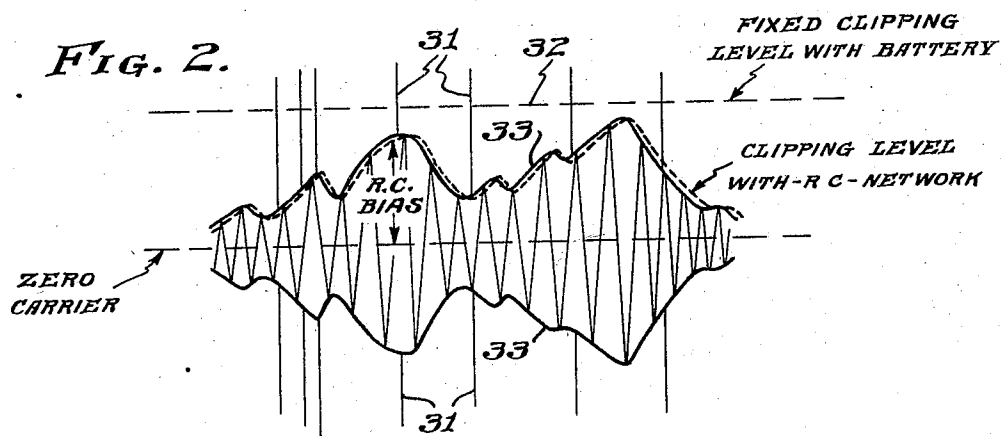
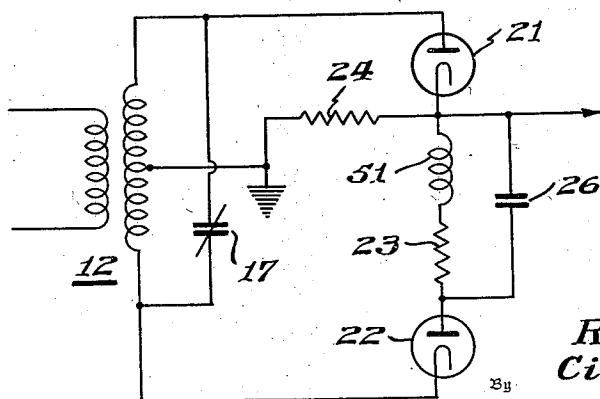


FIG. 4.



Inventors
Ralph S. Holmes,
Ciro C. Martinelli

J. J. Huff
Attorney

UNITED STATES PATENT OFFICE

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NOISE SUPPRESSOR

Ralph S. Holmes, Haddonfield, and Ciro C. Martinelli, Oaklyn, N. J., assignors to Radio Corporation of America, a corporation of Delaware

Application October 12, 1939, Serial No. 299,064.

5 Claims. (Cl. 178—5.8)

Our invention relates to the suppression of noise in receivers designed for the reception of modulated carrier waves, and particularly to the suppression of noise in television receivers.

An object of the invention is to provide an improved means for and method of reducing noise in the output of a radio receiver, particularly in either the sound or picture output of a television receiver.

A further object of the invention is to provide an improved noise suppressor circuit in which the suppressor action is not disturbed by variations in the strength of the incoming signals.

A still further object of the invention is to provide a noise suppressor circuit which removes substantially all the noise signal extending beyond the envelope of a sound modulated carrier wave.

In practicing the invention, a balanced diode circuit is employed which includes a network or filter across which a biasing voltage is developed for opposing current flow through one of the diodes. This network has a time constant at least fast enough to permit the biasing voltage to vary with variations in the strength of the incoming signals so that the signal to noise ratio will not be less than a predetermined value.

In one of the preferred embodiments of the invention the noise suppressor circuit is applied to the second detector in the sound channel of a television receiver where the pass band of this channel is made much wider than the frequency band of the sound signals. In this application the frequency characteristic of the biasing network preferably is made such that the biasing voltage varies in accordance with the envelope of the modulated carrier wave whereby all noise pulses of greater amplitude than that of the carrier envelope are balanced out. Since these noise pulses are of large amplitude and short duration because of the wide pass band of the sound channel, the result is that a large part of the noise signal is removed at the second detector and is not passed on to the audio amplifier. Thus at least a one-to-one signal to noise ratio is maintained. The unusual effectiveness of this embodiment of the invention is based upon the fact that as the frequency pass band of an amplifier channel is increased in width, the amplitude of a noise signal or pulse passed thereby is increased while its width or duration is decreased, the energy content of the noise pulse remaining unchanged.

In another embodiment of our invention, the

noise suppressor circuit is applied to the picture channel of a television receiver, preferably at the second detector.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which

Figure 1 is a block and circuit diagram of a television receiver embodying the invention,

Figure 2 represents a sound signal containing noise pulses as the said signal appears at the second detector in the circuit of Fig. 1,

Figure 3 represents the picture and synchronizing signals as they appear at the second detector in the picture channel in circuit of Fig. 1, and

Figure 4 is a circuit diagram illustrating a modification of the invention.

Referring to Fig. 1, there is shown a television receiver of the superheterodyne type comprising a first detector and tunable oscillator, represented by the block 1, which convert the incoming picture and sound modulated carrier wave to an intermediate frequency picture signal and to an intermediate frequency sound signal. The picture signal is supplied to the picture channel which includes an intermediate frequency amplifier 2, a second detector 3, a video amplifier 4 and a cathode ray tube 6. The usual horizontal and vertical deflecting circuits are supplied in the customary way with horizontal and vertical synchronizing pulses, respectively, through a suitable separating circuit 5 for removing the picture signal and through a suitable filter 10 for separating horizontal and vertical synchronizing pulses.

The sound modulated I. F. carrier wave is supplied to the sound channel which includes an I. F. amplifier 7, a second detector 8, an audio amplifier 9 and a loudspeaker 11.

From the foregoing it will be seen that the specific receiver illustrated in Fig. 1 is of the type described in Carlson Reissue 20,700, dated April 18, 1938, which is designed to receive picture and sound signals which are transmitted on carrier waves spaced apart by a frequency band of definite width.

The second detector 8 is coupled through a turned intermediate frequency transformer 12 to the last I. F. amplifier stage of the amplifier 7. The transformer 12 comprises a primary winding 13 and a secondary winding 14 tuned substantially to the mid-band frequency in the usual way by the condensers 16 and 17, respectively. Sufficient damping is provided, as by means of a resistor 18 connected across the

primary winding 13, to make the band-pass characteristic of the tuned transformer 12 flat and to make the frequency pass band much wider than the frequency band covered by the sound signals.

The tuned transformers or coupling circuits in the amplifier stages of the amplifier 7 may be substantially the same as the tuned transformer 12 or they may be any one of several other well known designs which have a wide pass band of the character above indicated.

The second detector 8 comprises a diode 21 and a diode 22, the diode 21 being the detector proper and the diode 22 being provided for the purpose of noise suppression. The cathode of one diode is connected to the plate of the other diode through a resistor 23 in the specific example shown in Fig. 1. The junction point of this cathode and the resistor 23 is connected through an output resistor 24 to the electrical mid-point of the secondary winding 14, which, in the example shown, is grounded. The other electrodes of the diodes 21 and 22 are connected to the ends of the secondary winding 14.

The resistor 23 and a condenser 26 connected thereacross are provided for the purpose of applying a variable biasing voltage to the diode 22, this bias preferably to vary at substantially the highest sound modulating frequency. As a result, that portion of any noise pulse which has an amplitude greater than that of the I. F. carrier wave envelope is balanced out whereby the amount of noise energy applied to the audio amplifier 9 is greatly reduced.

The operation of our invention can best be explained with reference to Fig. 2 which shows a sound modulated I. F. carrier wave which has noise pulses mixed therewith. Assume, for example, that instead of the RC network 23-26 there is a biasing battery which opposes current flow through the diode 22. So long as the applied signal has an amplitude below the value of this bias voltage the diode 22 is ineffective and the second detector diode 21 functions in the usual way. However, when an incoming signal such as a noise pulse exceeds this bias voltage (indicated in Fig. 2 by the dotted line 32) there is a flow of current through the diodes 21 and 22 which is balanced out at the output resistor 24. The noise energy represented by this flow of current is dissipated in the circuit 8 and thus does not reach the audio amplifier.

The operation of the circuit with the RC network 23-26 is similar to that described above except for the important difference that in the preferred embodiment the frequency characteristic of network 23-26 is made such that the bias produced thereacross will vary with or follow the sound envelope as indicated by the dotted line 33 in Fig. 2. Obviously, such an adjustment of the RC network causes a greater percentage of the noise energy to be dissipated in the circuit 8.

By way of example, it may be noted that in a television receiver having a sound channel designed to pass sound having a frequency band lying between approximately 60 cycles and 8000 cycles and where the sound I. F. channel was designed to pass a frequency band 200,000 cycles wide, the following values were used:

Resistor 23=20,000 ohms

Condenser 26=1,000 micro-microfarads

In this same receiver a tone control circuit was employed which comprises a resistor 36 and a condenser 37 connected in series and in shunt

to the RC network 23-26. By decreasing the value of resistor 36 the time constant of the RC biasing circuit is changed whereby the bias may be made to vary slower than the highest modulating frequency. In that case the higher frequency components of the sound signal are not passed on to the audio amplifier. Furthermore, the amount of noise energy passed on to the audio amplifier has been still further reduced. In the example being described, the tone control circuit values were as follows:

Resistor 36=100,000 ohms (maximum)

Condenser 37=0.025 microfarad

It will be understood that the variable tone control circuit 36-37 is not necessary for proper operation of the noise suppressor and may be omitted. It is described and claimed in the copending application Serial No. 395,346, filed May 27, 1941, in the name of Ralph S. Holmes and assigned to the Radio Corporation of America.

The sound channel may be provided with automatic volume control or AVC in the usual way by utilizing the direct current flow through the detector output resistor 24. The voltage produced by this current flow is applied through a smoothing filter comprising a resistor 38 and a condenser 39 to a direct current amplifier 40 which reverses the polarity of the AVC voltage before it is applied to the I. F. amplifier stages.

In accordance with another embodiment of our invention, an RC biasing network is employed which has a large time constant which may be the same as that employed in AVC circuits whereby the bias for opposing current flow in the diode 22 does not follow the sound envelope but, instead, varies only in accordance with the strength of an incoming signal. In this design, the tone control elements 36 and 37 are omitted and, if desired, the filter elements 38 and 39 may be omitted, the AVC voltage being applied directly from the junction point of the resistor 23 and the cathode of diode 21 to the I. F. amplifier 7.

Regardless of the adjustment of the RC biasing network 23-26, the I. F. amplifier 7 should be designed with suitable filter time constants as taught in copending application Serial No. 287,027, filed July 28, 1939, in the name of Ciro C. Martinelli and assigned to the Radio Corporation of America. As explained in this Martinelli application, "overhang" of noise pulses is prevented by making the voltage supply filters in the I. F. amplifier, such as the control grid circuit filter, have either a very short time constant or a very long time constant.

While we have described a specific RC biasing network for producing the desired variable bias which opposes current flow through the diode 22 it should be understood that the invention is not so limited. For example, in Fig. 4, where parts corresponding to those in Fig. 1 are indicated by like reference numerals, there is shown a bias producing network which includes an inductance coil 51 in addition to the resistor 23 and the condenser 26.

The use of the inductance coil 51 in the network may be desirable to increase its sharpness of cut-off at the high frequency and where the network time constant has been made small enough to make the bias follow the sound envelope more or less closely. Unless a tone control adjustment is desired which will lower the high frequency response, it is preferable that the RC network (23-26-51, for example) have a sharp cut-off just above the highest modulating fre-

quency. For most purposes, the simple RC network such as network 23—26 meets this desirable characteristic closely enough. In certain cases a network consisting of an inductance coil and a condenser only may be desirable, that is, a network as in Fig. 4 with the resistor 23 shorted out.

Referring now to the application of our invention to the picture channel of a television receiver as shown in Fig. 1, the second detector 3 is similar to the sound detector 8 and comprises the detector diode proper indicated at 41 and the noise suppressor diode 42. These diodes are connected in series conducting or cathode-to-plate relation and across the tuned band-pass transformer 43. The detector output resistor 44 is connected between the electrical mid-point of the secondary of transformer 43 and the junction point of the cathode of one diode and the plate of the other diode.

As in the case of the noise suppressor circuit shown in the sound channel, an RC network comprising a resistor 46 and a condenser 47 is employed to provide a bias which opposes current flow through the diode 42. This RC network may be located adjacent to the noise suppressor diode as previously described or it may be located at another point in the circuit as, for example, between the two halves of the secondary of the transformer 43. The time constant of the biasing network 46—47 is made rather large and such that the bias thereacross will vary at about the same rate as the usual AVC voltage. For example, the elements 46 and 47 may have the values one megohm and 0.25 microfarad, respectively, in a receiver designed to receive a 441 line interlaced picture with a field frequency of 60 vertical deflections per second.

As illustrated in Fig. 3, the voltage across network 46—47 is equal to the peak value of the synchronizing pulses whereby the clipping level is at this value. Thus all noise energy above this level is dissipated in the detector-suppressor circuit and is not applied to the video amplifier 4. It is assumed that the synchronizing pulses are in the direction of black in the picture, that negative modulation transmission is being employed, and that the direct current component of the picture is being transmitted. In that case, the peaks of the synchronizing pulses are held at a fixed level, i. e., at maximum carrier amplitude, as illustrated. In this embodiment of the invention, as in the embodiment previously described, the I. F. amplifier should be designed with suitable filter time constants in accordance with the teachings of the above-identified Martinelli application.

In a television receiver employing our noise suppressor circuit, the voltage appearing across the RC biasing network in the picture channel may be utilized for providing automatic volume control. For example, in the circuit of Fig. 1, the voltage produced across the network 46—47 may be applied through a direct current amplifier 50 to suitable gain control electrodes in the I. F. amplifier tubes. The amplifier 50 reverses the polarity of the voltage taken off the network 46—47 so that the AVC voltage varies with a change in the strength of an incoming signal to decrease the gain of the I. F. amplifier 7 in response to an increase in the signal strength.

From the foregoing, it will be apparent that our invention is useful in either a receiver sound channel or picture channel for reducing the

amount of noise appearing in the channel output and that it causes the clipping level (or signal level beyond which noise is eliminated) to vary in the desired manner with variations in the strength of the incoming signal. It will also be apparent that we have provided an unusually effective noise suppressor for use in the sound channel of a television receiver.

Various modifications of the invention, in addition to those described, may be made without departing from the spirit and scope thereof, and we desire, therefore, that only such limitations shall be imposed thereon as are necessitated by the prior art and are set forth in the appended claims.

We claim as our invention:

1. In a receiver of the superheterodyne type for the reception of a carrier wave modulated by a sound signal, means for converting said modulated carrier wave to a modulated intermediate frequency carrier wave, a wide band intermediate frequency amplifier for amplifying said intermediate frequency carrier wave, said amplifier having a pass band several times the width of the frequency band occupied by said sound signal, noise suppressor means for clipping off and dissipating substantially all noise-signal energy which exceeds in amplitude the amplitude of a biasing or limiting voltage which varies in amplitude in accordance with the envelope of said modulated intermediate frequency carrier wave, said noise suppressor means comprising a diode having a network in series therewith across which said limiting voltage appears, said network comprising a resistor having a capacitor connected thereacross and having a time constant such that said limiting voltage may vary at approximately the same rate as the highest frequency component in the said band of frequencies to be passed, a reproducing device, and an audio amplifier through which the resulting substantially noise-free signal is supplied to said reproducing device.

2. In a receiver of the superheterodyne type for the reception of a carrier wave modulated by a sound signal, means for converting said modulated carrier wave to a modulated intermediate frequency carrier wave, a wide band intermediate frequency amplifier for amplifying said intermediate frequency carrier wave, said amplifier having a pass band several times the width of the frequency band occupied by said sound signal, a balanced second detector and noise-suppressor circuit coupled to said intermediate frequency amplifier through a coupling network having a winding across which said intermediate frequency signal appears, a pair of diodes connected in series with each other and said winding and in series-conducting relation, an output resistor connected between the electrical midpoint of said winding and the junction point of said diodes, a filter network connected in series with one of said diodes only for producing a biasing or limiting voltage-opposing current flow through said one diode, the time constant of said network being such that said biasing voltage at least approximately follows the envelope of said intermediate frequency signal, and an audio amplifier coupled across said output resistor.

3. In a receiver of the superheterodyne type for the reception of a carrier wave modulated by a sound signal, means for converting said modulated carrier wave to a modulated intermediate frequency carrier wave, a wide band intermediate frequency amplifier for amplifying

said intermediate frequency carrier wave, said amplifier having a pass band several times the width of the frequency band occupied by said sound signal, a balanced second detector and noise-suppressor circuit coupled to said intermediate frequency amplifier through a coupling network having a winding across which said intermediate frequency signal appears, a pair of diodes connected in series with each other and said winding and in series-conducting relation, an output resistor connected between the electrical midpoint of said winding and the junction point of said diodes, a network comprising a resistor and a condenser connected in parallel with each other and in series with one of said diodes only for producing a biasing or limiting voltage-opposing current flow through said one diode, the time constant of said network being such that said biasing voltage at least approximately follows the envelope of said intermediate frequency signal, and an audio amplifier coupled across said output resistor.

4. In a television receiver, a picture channel, a balanced circuit in said channel for detection and noise suppression which comprises a pair of diodes, each having a plate and a cathode, a coupling network having a winding through which a modulated carrier wave is impressed across said diodes, said diodes being connected in series with each other and said winding with the plate of one diode connected to one end of said winding and with the cathode of the other diode connected to the other end of said winding,

ing, an output resistor connected between the electrical mid-point of said winding and the other cathode and plate of said diodes, and a biasing circuit comprising a resistor and condenser in parallel which is connected in series with one of said diodes whereby a bias voltage appears across said resistor which opposes current flow through said one diode, the time constant of said biasing circuit being such that said bias voltage varies at substantially the same rate and in accordance with variations in the strength of the incoming signal.

5. In a television receiver for the reception of picture signals and synchronizing pulses wherein the said pulses have an amplitude exceeding the peak amplitude of picture signals of like polarity, a winding across which said signals and pulses appear, a combined detector and noise suppressor circuit which comprises a pair of diodes connected in series with each other and said winding and in series-conducting relation, an output resistor connected between the electrical midpoint of said winding and the junction point of said diodes, and a network comprising a resistor and a condenser connected in parallel with each other and in series with one of said diodes only for producing a biasing or limiting voltage opposing current flow through said one diode, the time constant of said network being such that said condenser discharges only slightly between successive synchronizing pulses.

RALPH S. HOLMES.
CIRLO C. MARTINELLI.