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NOISE REDUCTION SYSTEM

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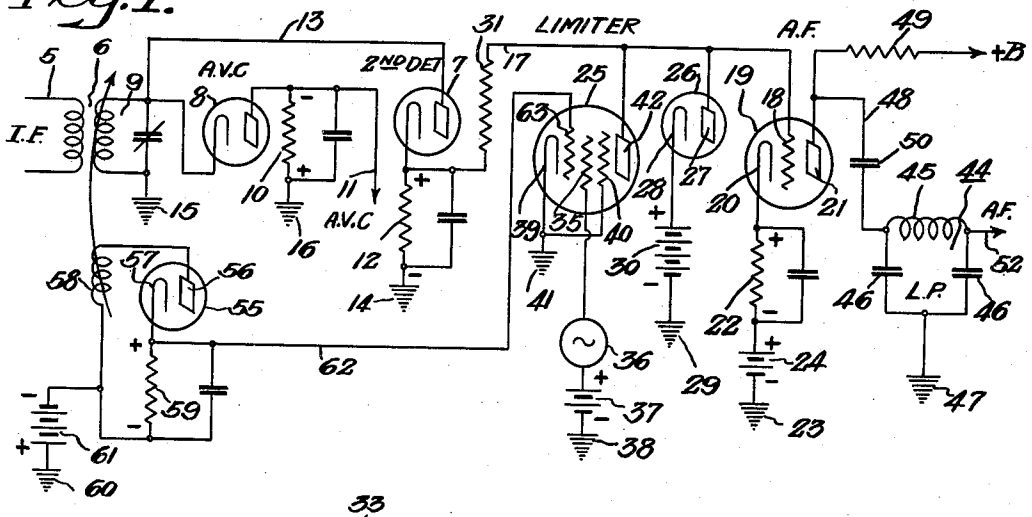
Fig. 1.



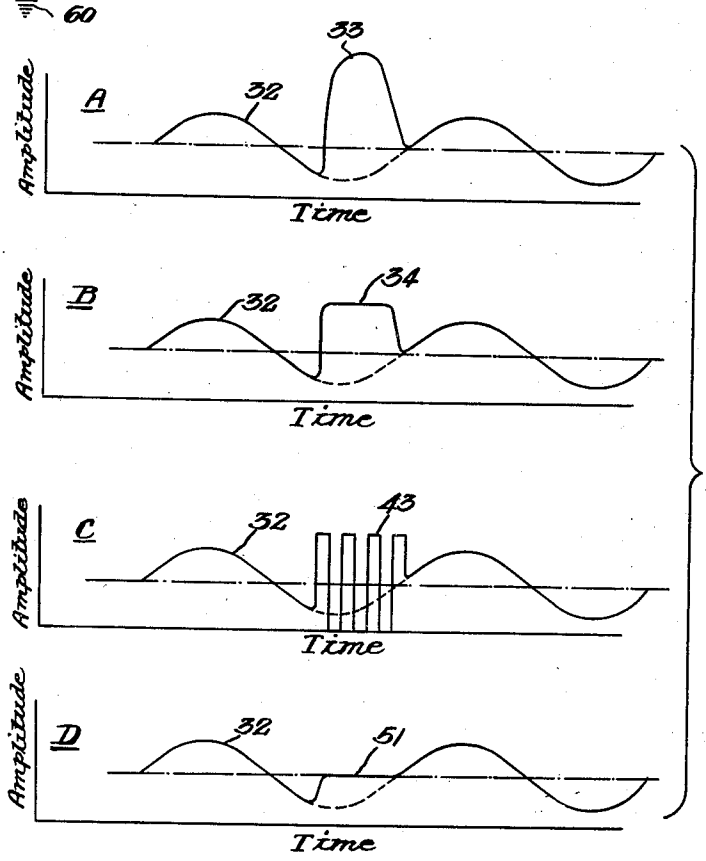


Fig. 2.

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NOISE REDUCTION SYSTEM

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10 Claims. (Cl. 250—20)

The present invention relates to a noise reduction system for radio receiving apparatus and the like, which operates to suppress the signal output of the receiving system during a pulse of noise voltage to which the receiving system may be subjected in operation.

It is an object of the present invention to provide a noise reduction system for radio receiving apparatus and the like which operates to break up the noise impulse at a high frequency rate whereby it is prevented from passing through a low-pass or audio-frequency-pass filter.

It is a further object of the present invention to provide an improved noise reduction system for a superheterodyne receiver, which may be applied to the second detector circuit, whereby a filter in the audio frequency output circuit from the second detector may be utilized in conjunction with means for breaking up a noise impulse in the detector output circuit, to reduce the amplitude of a noise impulse below the level of the signal amplitude in that circuit.

It is also a further object of the invention to provide a noise limiter system which may be applied effectively to a second or audio frequency detector circuit of a superheterodyne receiver.

The invention will be better understood, however, from the following description when considered in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing, Figure 1 is a schematic circuit diagram of a noise reduction system for a radio receiver, embodying the invention, and

Fig. 2 is a series of curves illustrating the mode of operation of the system of Fig. 1.

Referring to Fig. 1, a modulated signal input circuit is indicated at 5 which may be the output circuit of an intermediate frequency amplifier (not shown) for which the coupling transformer 6 serves as an output coupling device for the second or audio frequency detector 7 of a superheterodyne receiving system, and an automatic volume control device 8 for the system, both of which are diode rectifiers in the present example. The detector and automatic volume control devices are connected to a tuned secondary circuit 9 in connection with the transformer 6, which circuit is responsive to the intermediate frequency of the receiver. The automatic volume control device is provided with a suitable output resistor 10 from which is taken automatic volume control potentials for controlling the receiver through the lead 11, in any suitable and well known manner.

The rectifier 7 is also provided with a diode output resistor 12, the diode circuit being completed from the tuned circuit 9 through a supply lead 13 to the rectifier 7, and thence through the output resistor 12 to ground 14 and returning through ground 15 to the tuned circuit 9. The automatic volume control diode output resistor 10 likewise is provided with a ground return 16 to the input circuit 9.

Audio frequency signals derived from the output resistor 12 of the detector 7 are conveyed through a lead 17 to the control grid 18 of a first stage audio frequency amplifier tube 19, having a cathode 20 and an output anode 21. The cathode is connected through a self-bias resistor 22 with the chassis or ground 23, the connection including a biasing battery or potential source 24 having a polarity as indicated, whereby the potential of the source 24 is added in series, to the potential of the self-bias source 22. It will be noted that the polarity of the output resistor 12 is such that the detector direct current output voltage developed across said resistor serves to oppose the potential of the sources 22 and 24 in the grid circuit comprising the lead 17, the resistor 12, the ground connections 14 and 23 and the potential sources 24 and 22 between the grid 18 and the cathode 20 of the amplifier device 19. The arrangement is such that as highly modulated signals are applied to the second detector, the amplifier device 19 is caused to operate normally as an amplifier without distortion.

The audio frequency output circuit for the detector, which is represented by the lead 17 and ground, and which in the present example is connected with a first stage audio frequency amplifier 19 as described, is further provided with a noise suppressor pentode amplifier device 25 and a diode rectifier device or limiter 26, both of which are connected in shunt relation to the audio frequency circuit.

In the present example, the diode rectifier or limiter 26 is provided with an anode 27, connected with the audio frequency circuit lead 17, and having a cathode 28 connected with ground 29 through bias potential supply means 30 for the diode, comprising a battery in the present example. For the purpose of permitting the diode 26 to limit signal or noise peaks, a series resistor 31 is provided in the audio frequency circuit 17 between the diode and the detector output resistor 12.

The arrangement is such that as signals having peak amplitudes greater than the potential of the battery 30 are received in the audio frequency

circuit, the diode serves to rectify the positive peaks thereof, thereby limiting their amplitude.

In order that the limiting action may take place above the level of the desired signal, the voltage of the source **30** may be adjusted to equal substantially 100% modulation. The polarity of the biasing battery is such that the cathode **28** is at the predetermined positive potential with respect to the anode **27** sufficient to prevent rectification at amplitudes below 100% modulation.

The limiting action occurs when the diode rectifier or limiter **26** begins to draw current from the detector output resistor **12** through the potential drop producing series resistor **31** thereby preventing the application of excessively high noise potentials to the audio frequency amplifier **19**.

Referring to Fig. 2, the curve A shows an alternating current signal wave **32** which may be an audio frequency signal at any frequency such as 1000 cycles, on which occurs a noise impulse **33** greater than 100% modulation and on which the diode limiter operates to produce a flattening of the top of the impulse wave as indicated by the curve B at **34**.

In order to break up the limited noise impulse into a series of short impulses, the noise reduction pentode **25** is employed as a chopping limiter to introduce into the audio frequency system at the time of the impulse, a high frequency impulse, preferably super-audible, and under control of the noise impulse.

For this purpose, an electrode, preferably the screen grid **35**, of the pentode, is connected to a source of high frequency oscillations **36**, and a screen grid potential supply source **37** having a ground connection **38** to the common return circuit for the system. The cathode **39** and suppressor grid **40** are also connected with ground as indicated at **41**.

The super-audible high frequency impulses from the generator **36** are applied to the audio frequency output circuit **17—38** through the pentode device **25**, the anode **42** of which is connected with the audio frequency circuit lead **17**, thereby placing the space path of the pentode device **25** in shunt across the audio frequency circuit in parallel with the diode limiter **26**.

The noise impulse transmitted through the audio frequency circuit is thereby broken into a series of impulses indicated at **43** on the curve C of Fig. 2. This super-audible wave then representing and resulting from the noise impulse, is substantially removed from the audio frequency system by a suitable low pass filter **44** in the audio frequency circuit at any suitable point following the noise reduction and limiting circuit. In the present example, the filter comprises a series choke coil **45** and by-pass capacitors **46** to ground **47** connected with the output circuit **48** for the anode **21** of the first stage audio frequency amplifier **19**. The coupling is provided through a suitable anode output resistor **49** and coupling capacitor **50**.

The filter **44** serves to remove the impulses by filtering action to produce the reduced noise peak indicated at **51**, in connection with the curve D of Fig. 2. The filtered audio frequency current is applied to any suitable utilizing circuit through an output lead indicated at **52**.

In order that the noise reduction chopping wave or signal may be applied to the audio frequency circuit only when a noise impulse is received, a control circuit for the noise reduction pentode is provided. This comprises a diode rectifier device **55** having an anode **56** and a cathode **57** connected with an input circuit comprising an untuned coupling winding **58** and having an output circuit including output resistor **59** and completing a diode rectifier circuit. The diode output resistor operates with the polarity shown and receives energy through the rectifier device from the coupling winding which is inductively coupled with the signal channel, for example, through a coupling indicated in the drawing, with the secondary of the intermediate frequency output transformer **6**.

The negative terminal of the control diode output resistor **59** is connected to ground **60** through a source of biasing potential **61**, the positive terminal of which is connected with ground. The positive terminal of the resistor **59** is connected through a bias supply lead **62** with the control grid **63** of the pentode device **25** thereby operating to apply to the grid **63** a negative biasing potential from the source **61** through the control diode output resistor **59**.

In the presence of signals, the additional potential in series with the grid **63** and the cathode **39** is provided by the output resistor **59** of the control diode which potential is in opposition to the normal biasing potential and varies with the signal strength. The arrangement is such that the normal biasing potential provided by the source **61** is sufficient to bias the noise reduction pentode substantially to cut-off and to maintain it in the cut-off range for signals below 100% modulation, whereby the oscillations from the source **36** are prevented from being applied to the audio frequency output circuit from the detector until a strong noise impulse is received which permits the pentode to function.

From the foregoing description, it will be seen that a noise reduction system for a radio receiver in accordance with the invention operates to break up the noise impulse or voltage wave at a high frequency rate in the audio frequency circuit following the signal rectifier or audio frequency detector. After the resultant wave is passed through the low pass filter, the output during the pulse will be very nearly zero. The noise impulse in the audio frequency circuit may be broken up by super-audible or high frequency oscillations and the high frequency component of the noise impulse may then be filtered out by the low pass filter. Since this limiter and noise reduction circuit is included in connection with the second or audio detector of a receiver, the low pass filter may be an audio frequency filter having a cut-off point above the audio frequency range. The energy of the high frequency component or super-audible components of the noise impulse will then be materially reduced in the audio frequency output circuit.

It is desirable in order to provide a condition of operation wherein the area of the impulse wave above and below the normal carrier level may be substantially the same, that the diode limiter should be adjusted for operation at substantially double the normal output voltage produced by the carrier wave which condition is met by adjusting the limiter for operation at peak potential above 100% modulation peak. The voltages on the noise reduction pentode are preferably adjusted to provide a symmetrical rectangular wave shape for interrupting the noise impulse as indicated in Fig. 2C.

The low pass filter should be arranged to pass substantially the same or somewhat smaller, band of audio frequency signals as will be produced in

the second detector by the interaction of the carrier and such side bands as will be permitted to reach the second detector through the selectivity provided by the signal selecting and receiving circuits such as the intermediate frequency circuit 5—6—9.

I claim as my invention:

1. The combination with a radio receiver having an audio frequency detector subject to noise impulses and having an audio frequency signal output circuit through which said noise impulses and desired signals are conveyed from said detector, of means for breaking up in said output circuit said noise impulses at a relatively high and super-audible frequency, and means for reducing the audio frequency output during the noise impulses to substantially zero comprising a signal and impulse limiter operative about a mean zero modulation axis and a low pass filter following said audio frequency output circuit.

2. In a superheterodyne radio receiving system, the combination with the second detector thereof, of an audio frequency signal output circuit for said detector, means connected with said circuit providing a signal peak limiter for maintaining the amplitude of received noise impulses below a predetermined high level, an electric discharge amplifier coupled to said output circuit, means for applying oscillations to said circuit through said amplifier, and means for controlling said amplifier in response to received noise impulses to permit the amplifier to operate only in response to impulses above a predetermined amplitude.

3. In a radio receiver, the combination with signal receiving means, of an audio frequency detector for received signals, an audio frequency amplifier coupled thereto having a low pass filter in the output circuit thereof, a diode signal limiter device connected in circuit between said detector and said audio frequency amplifier to limit signals transmitted from said detector to said amplifier to predetermined peak values, and means for introducing super-audible oscillations into the audio frequency circuit between said detector and said audio frequency amplifier in response to noise impulses having peak values above said predetermined values.

4. In a radio receiver, the combination with modulated signal receiving means, of an audio frequency detector for received signals, an audio frequency amplifier coupled thereto having a low pass filter in the output circuit thereof, a diode signal limiter device connected in circuit between said detector and said audio frequency amplifier to limit signals transmitted from said detector to said amplifier, biasing means for the limiter device to prevent operation thereof on noise and signal peaks below 100% modulation, means for introducing super-audible oscillations into the audio frequency circuit between said detector and said audio frequency amplifier, and means connected with said last named means for operating the same in response to noise impulses having peak values above 100% modulation.

5. A noise reduction system including in combination, a diode signal rectifier having an audio frequency output circuit, an audio frequency signal limiter connected with said audio frequency output circuit, means for adjusting said limiter to operate in response to signal peaks having amplitudes above a predetermined high audio signal peak, an electric discharge device having its space path connected in parallel with said audio frequency circuit, means for introducing super-audible oscillations into said audio frequency circuit through said electric discharge device to interrupt a noise impulse and including an electrode in said device and an oscillation generating device connected therewith, said electric discharge device further having a gain control electrode, means for biasing said gain control electrode to prevent oscillations from being applied to said audio frequency output circuit through said device in the presence of signals of normal amplitude, means responsive to signal impulses of a predetermined high value for causing said electric discharge device to operate to transmit said oscillations to said audio frequency output circuit, and a low pass filter in connection with the audio frequency output circuit following said limiter for removing the super-audible component of the noise impulses.

6. In a radio receiving system of the superheterodyne type, the combination of a diode second detector having a diode output resistor the negative terminal of which is connected with the receiving system ground, a diode rectifier device having a diode output resistor the negative terminal of which is connected to said ground through an opposing source of biasing potential, means for applying received modulated signals to said detector and rectifier, an audio frequency output lead connected with the positive terminal of said detector output resistor, an audio frequency amplifier device having a control grid connected to said output lead, an audio frequency output circuit for said amplifier device, a low pass filter in said last named output circuit, a third diode rectifier device and a pentode electric discharge device having space paths connected in parallel across the audio frequency output circuit of said detector between said output lead and said ground, a series limiting resistor in said output lead adjacent to the detector output resistor and biasing potential supply means for said third diode rectifier whereby the latter operates as a signal limiter for signal peaks above a predetermined amplitude, means for applying high frequency oscillations to an electrode of said pentode device, and means for applying a controlling potential from said second diode rectifier output resistor to the control grid of said pentode device whereby it is rendered operative to apply said oscillations to the audio frequency circuit in the presence of noise impulse peaks above said predetermined amplitude.

7. A noise reduction system including in combination, a diode signal rectifier having an audio frequency output circuit, an audio frequency signal limiter connected with said audio frequency output circuit, means for adjusting said limiter to operate in response to signal peaks having amplitudes above a predetermined high value, an electric discharge device having its space path connected in parallel with said audio frequency circuit, means for introducing super-audible oscillations into said audio frequency circuit through said electric discharge device to interrupt a noise impulse, means responsive to signal impulses above said predetermined high value for causing said electric discharge device to operate to transmit said oscillations to said audio frequency output circuit, and a low pass filter in connection with the audio frequency output circuit following said limiter for removing the super-audible component of the noise impulses.

8. In a radio receiving system having an audio frequency detector subject to noise impulses and having an audio frequency signal output circuit

through which said noise impulses and desired signals are conveyed from said detector, the combination of a diode rectifier connected across said audio frequency signal output circuit to provide a signal limiter for said circuit, means connected with said rectifier for causing the limiting action to take place above a desired signal level, means providing a source of super-audible oscillations, a noise reduction device through which said oscillations are applied to said signal output circuit, said device having a control electrode, means for deriving a control potential for said electrode which varies in accordance with the strength of received signals, and means providing a low pass filter following said audio frequency signal output circuit for removing from the signal output the super-audible component of an interrupted noise impulse.

9. In a radio receiving system, means providing noise reduction comprising an audio frequency detector having an output circuit, means connected with said output circuit for interrupting therein a noise impulse in a series of super-audible waves, means connected with said output circuit providing a low pass filter therein for removing said super-audible waves, and said first named means including a tube having its space path connected across said output circuit and having two control grids, an oscillator connected to one of said grids for applying thereto a super-audible wave and a signal rectifier having an output circuit connected with the other of said grids for applying the rectified signal component thereto above a predetermined amplitude.

10. In a radio receiving system, means providing noise reduction comprising an audio frequency detector having an output circuit, an impulse limiter connected with said output circuit, means connected with said output circuit for interrupting therein a limited noise impulse in a series of super-audible waves, and means connected with said output circuit providing a low pass filter therein for removing said super-audible waves.

WINFIELD R. KOCH.