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NOISE LIMITING CIRCUITS

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Fig. 1.

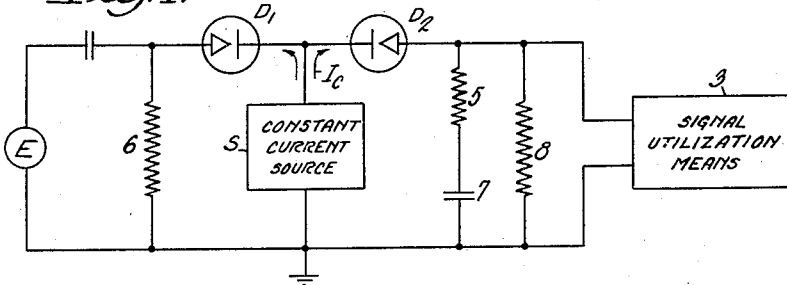


Fig. 2.

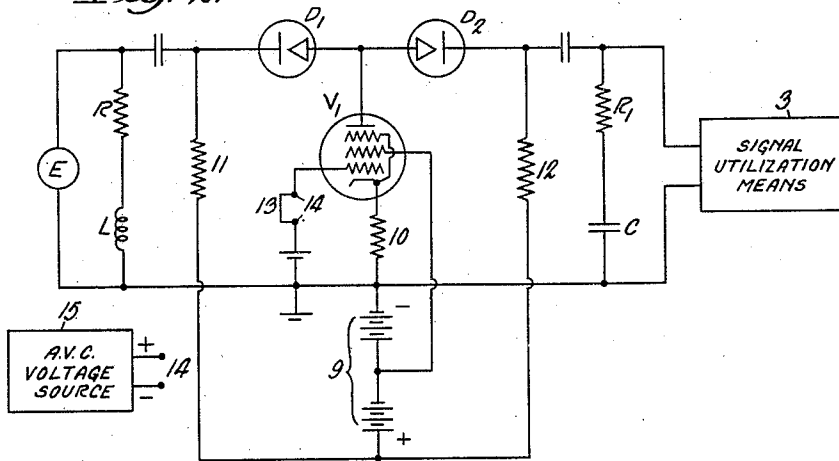
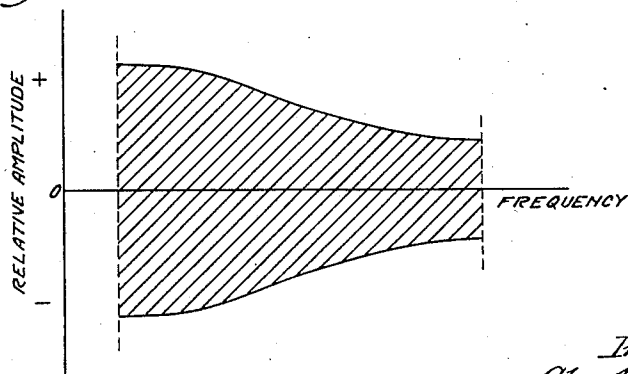


Fig. 3.



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NOISE LIMITING CIRCUITS

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This invention relates to noise limiting circuits and has for its general object to provide improved means for limiting the amplitude of interfering noise pulses or signals in communication or control systems and the like.

In systems employed in the transmission of television signals, speech, music, and the like, it has been noted that the amplitudes of the various component frequencies usually vary approximately as an inverse function of frequency. Thus normally only the lower frequencies attain the maximum signal amplitude, while the higher frequencies may be of relatively low amplitude.

An ideal noise limiting circuit for such systems would be one which would limit noise pulses accompanying low frequency signals to a level comparable to that of the maximum low frequency signal amplitude, and which would limit noises accompanying higher frequency signals to a lower level comparable to the maximum level of the higher frequency signals. The present invention provides such a system.

According to one feature of the invention, there is provided in a noise limiting circuit, a source of signals and a utilization means therefor, signal transfer means therebetween including a serially connected non-linear impedance means, means for supplying said non-linear impedance means with a biasing or polarizing current whereby said transfer means is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, and frequency selective circuits associated with said non-linear impedance means whereby said cut-off amplitudes are a function of the signal frequency.

According to another feature of the invention there is provided in a noise limiting circuit, a source of signals and a utilization means therefor, signal transfer means therebetween including a pair of serially connected but mutually reversed non-linear impedance means, means for supplying said non-linear impedance means with a biasing or polarizing current whereby said transfer means is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, and frequency selective circuits associated with said non-linear impedance means whereby said cut-off amplitudes are a function of the signal frequency.

The invention may be understood by reference to the accompanying drawing, wherein—

Fig. 1 is representative of one form of the invention;

Fig. 2 is representative of a preferred embodiment; and

Fig. 3 illustrates a possible cut-off amplitude characteristic as a function of frequency.

Referring generally to Figs. 1 and 2, E represents a source of signals comprising a certain band of frequencies, such as the audio frequencies normally employed in radio reception or the like. A signal utilization means 3 is coupled to the signal source E by way of a signal transfer means which may include one or a plurality of serially connected non-linear impedance means such as diodes D_1 and D_2 , together with certain associated circuit elements having frequency discriminatory characteristics, such as the resistor-capacitor combinations 5—7 and R_1C . Where a pair of diodes is employed, the diodes are preferably serially connected with respect to the signal transfer path, but are mutually reversed, as illustrated in Figs. 1 and 2. The signal E may be derived from the usual second detector circuits of a superheterodyne radio receiver from an audio frequency amplifier, or from any other suitable source. The signal utilization means 3 may comprise the usual audio amplifier and loudspeaker, as are well known in the art.

Attention is now directed more specifically to Fig. 1 where, in accordance with one embodiment of the invention, a substantially constant current, I_c , from a suitable source S is introduced to the diodes D_1 and D_2 at their juncture whereby both diodes are maintained in a conductive state for all signals which do not reduce the current through the one or the other diode to zero. The resistors 6 and 8 are provided mainly to complete the direct current paths for the constant current I_c which is divided between the two diodes as indicated. It should be observed that with respect to I_c , which is derived from the source S, the diodes D_1 and D_2 are effectively in parallel, while with respect to the signal transfer path which extends between the signal source E and the signal utilization means 3, they are in series and mutually reversed.

Assume, by way of example, that the source S supplies a substantially constant current of 2 milliamperes. Under no-signal conditions this current will divide equally between the two diodes, 1 ma. proceeding to the left through the diode D_1 and 1 ma. proceeding to the right through D_2 . If now the signal source E supplies an alternating current having a peak value of one-half ma. to the signal utilization means 3, the current in the diodes will vary between limits of 0.5 and 1.5 ma., but because the biasing current

flows through the diodes in opposite directions with respect to the signal path from E to the device 3 (i. e. from cathode to anode in one and from anode to cathode in the other), the individual diode currents will vary oppositely with respect to one another. Thus when the current in D_1 is 0.5 ma. the current in D_2 will be 1.5 ma., and conversely. Hence the sum of the diode currents will be substantially constant at 2.0 ma., which is the value of current supplied by the constant current source S. If the signal source E supplies an alternating current having a peak value of 1 ma. the current in the diodes will vary between limits of 0 and 2 ma., but since the absolute values of diode current vary in opposite sense the total diode current will again remain substantially constant at 2 ma., the current supplied by the constant current source S. Where, due to noise conditions or the like, the peak signal supplied by the source momentarily exceeds the limiting value of 1 ma., the current in the two diodes will momentarily assume the limiting values of 0 and 2 ma. respectively, the current supplied by the source S remaining substantially constant at 2 ma.

It will now be understood that when the amplitude of the input signal E exceeds a certain threshold value, the instantaneous current in one or the other of the diodes will be reduced to zero, and accordingly the diode path D_1 — D_2 will be broken and incapable of transmitting signals exceeding such a threshold level. Assuming a symmetrical diode circuit, this limiting threshold level may be made to appear symmetrically on both sides of the zero signal axis, and hence both the positive and negative halves of the signal cycles may be similarly limited. By suitably choosing the value of the constant current I_c derived from the source S, the threshold or cut-off level of the diodes may be made approximately equal to the maximum desired signal amplitude. Noise signals exceeding this level will accordingly be limited to this predetermined cut-off level by the open-circuiting action of the diode path.

It has been found, however, that the amplitudes of the desired audio frequency components which comprise the usual broadcast programs of speech, music, or the like, usually vary according to some inverse function of frequency whereby only the lower audio frequencies attain the maximum signal amplitudes. Accordingly it is an important feature of this invention to provide means whereby the cut-off level of a noise limiter may be made to vary with frequency in such a way as to take advantage of the above fact. In Fig. 1 this desirable feature is attained by associating with the diodes D_1 and D_2 a suitable frequency selective or discriminatory network which may comprise, for example, a resistor 5 and a capacitor 7. The effect of this network is to increase the signal current passing through the diodes at the higher audio frequencies, thus effectively lowering the cut-off level of the transfer path at these frequencies. At the lower frequencies, where the impedance of the network 5—7 is high compared to that of the resistor 8 the variation of cut-off level with frequency will of course be small. Similarly, at the highest frequencies, where the impedance of the capacitor 7 is very small compared to that of the resistor 5, the variation of cut-off level with frequency will likewise be small.

Such a characteristic of cut-off level vs. frequency is illustrated in Fig. 3. This figure represents the general characteristics of a circuit such as that shown in Fig. 1. By making the direct

current paths of the two diodes dissimilar, as by making the resistance of resistor 6 greater or less than that of the resistor 8, a cut-off characteristic can be secured which is unsymmetrical about the zero axis. Moreover, if amplitude limitation is not required for a particular polarity of signal, one of the diodes may be removed from the circuit and replaced by a simple conductor, thus giving amplitude limitation for only the negative, or the positive, alternations, as the case may be. Accordingly, the invention is not to be limited to the use of two diodes, since in some applications it may be found that noise pulses extend largely in one direction from the zero axis, in which event a single diode can provide all desired amplitude limitation.

In Fig. 1, the constant current source S has been indicated only in a general way, there being a number of ways in which such a constant current source may be secured. If desired, the source S may comprise a high voltage battery in series with a resistance which is high compared to all other resistances in the direct current diode circuits.

It may be observed that the circuit of Fig. 1 will tend to discriminate against the higher signal frequencies due to the network which comprises the resistors 5 and 8 and the capacitor 7, which is similar to networks employed in bass-compensating tone controls and the like. This discrimination against the higher desired signal frequencies is not an inherent characteristic of the present invention however, and if it is desired to avoid this effect, a constant resistance network may be employed similar to that shown in Fig. 2. The constant resistance network employs the resistors R and R_1 , the inductor L and the capacitor C . If the resistors R and R_1 are of equal resistance R , and if $(R)^2$ be made equal to L/C , the resistance looking into the network will be constant for all frequencies, and hence the network will not discriminate unequally against component signal frequencies having amplitudes below the cut-off level of the system. In this circuit, as the signal frequency increases, the current through the shunt path R_1C increases and hence also the signal current through the diodes, while the current through the shunt path RL decreases. Accordingly, the diodes will limit signals of higher frequencies to a lower relative amplitude level than that at which the lower signal frequencies are limited, and thus the cut-off characteristic of Fig. 3 is likewise generally descriptive of the operation of the circuit of Fig. 2.

In the circuit of Fig. 2 there is shown a preferred form of constant current source comprising a battery 9 and a pentode V_1 with cathode load 10, whose first grid is returned to a point on the cathode load remote from the cathode. The resistors 11 and 12 provide constant current paths for the diodes D_1 and D_2 respectively. It has been found that such a pentode circuit provides a highly constant source of direct current, due firstly to its inherently high plate impedance, and secondly due to the degenerative action which effectively tends very substantially to increase the apparent resistance in the pentode circuit by a factor which is a direct function of the amplification factor of the tube.

It should be obvious, of course, that in either of the circuits shown it will be possible to secure almost any characteristic of cut-off amplitude vs. frequency that might be desired merely by providing the proper type of frequency discriminatory or selective network. Thus in Fig. 2 a char-

acteristic might be obtained which is just the reverse of that shown in Fig. 3 merely by interchanging the capacitor C and the inductor L.

In the foregoing, it has been assumed that I_c is held constant. However, it may be desirable in some instances to have I_c vary in accordance with certain conditions. Thus, if E be taken as the output of the second detector in a superheterodyne radio receiver, it might be well to have I_c vary as some direct function of the detector output level. In this way, the limiter could be made to operate effectively under a wide range of conditions, regardless of variations in signal strength and the like. For example, in Fig. 2 the short-circuiting conductor 13 might be removed from the terminals 14, and a voltage source 15 connected thereacross whose voltage varies directly with the average amplitude of the modulated intermediate frequency carrier wave, as is well known in the automatic volume control art.

Although the invention has been described with particular reference to the embodiments of the drawing, it will be understood that the invention is capable of various forms of physical expression, and is not to be limited to the specific disclosure, but only by the scope of the appended claims.

I claim:

1. A noise limiting circuit comprising a source of signals and a utilization means therefor, signal transfer means therebetween including a serially connected non-linear impedance means, means for supplying said non-linear impedance means with a biasing current, whereby said transfer means is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, and frequency selective circuits operatively associated with said non-linear impedance means for varying said cut-off amplitudes according to a function of the signal frequency.

2. A noise limiting circuit comprising a source of signals and a utilization means therefor, signal transfer means therebetween including a pair of serially connected but mutually reversed non-linear impedance means, means for supplying said non-linear impedance means with a biasing current, whereby said transfer means is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, and frequency selective circuits operatively associated with said non-linear impedance means for varying said cut-off amplitudes according to a function of the signal frequency.

3. A noise limiting circuit in accordance with claim 2, characterized in that the non-linear impedance means comprises a pair of mutually reversed vacuum tube diodes.

4. A noise limiting circuit having high and low potential input and output terminals, connections between said low potential input and output terminals, a pair of serially connected, mutually reversed diodes connected between said high potential input and output terminals, a voltage source for supplying said diodes with a biasing current, said biasing voltage source being connected between the low potential side of said circuit and the junction between said diodes, whereby the diode path is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, and a frequency selective circuit associated with said diodes whereby said cut-off amplitudes are caused to vary with the signal frequency.

5. A noise limiting circuit in accordance with claim 4, wherein said frequency selective circuit comprises a resistor and a capacitor connected in series and shunted across said output terminals.

6. A noise limiting circuit having high and low potential input and output terminals, connections between said low potential input and output terminals, a pair of serially connected, mutually reversed diodes connected between said high potential input and output terminals, a voltage source for supplying said diodes with a biasing current, said biasing voltage source being connected between the low potential side of said circuit and the junction between said diodes, whereby the diode path is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, means for maintaining said biasing current substantially constant, and a frequency selective circuit associated with said diodes whereby said cut-off amplitudes are caused to vary with the signal frequency.

7. A noise limiting circuit having high and low potential input and output terminals, connections between said low potential input and output terminals, a pair of serially connected, mutually reversed diodes connected between said high potential input and output terminals, a voltage source for supplying said diodes with a biasing current, said biasing voltage source being connected between the low potential side of said circuit and the junction between said diodes, whereby the diode path is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, means for varying the magnitude of said biasing current in accordance with the average amplitude of the modulated carrier wave, and a frequency selective circuit associated with said diodes, whereby said cut-off amplitudes are caused to vary with the signal frequency.

8. A noise limiting circuit comprising a source of signals and a utilization means therefor, signal transfer means therebetween including a serially connected non-linear impedance means, means for supplying said non-linear impedance means with a biasing current, whereby said transfer means is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, said biasing means comprising a source of unidirectional current in series with the plate circuit of a degeneratively connected vacuum tube, and frequency selective circuits associated with said non-linear impedance means, whereby said cut-off amplitudes are a function of the signal frequency.

9. A noise limiting circuit having high and low potential input and output terminals, connections between said low potential input and output terminals, a pair of serially connected, mutually reversed diodes connected between said high potential input and output terminals, a voltage source connected between the low potential side of said circuit and the junction between said diodes for supplying said diodes with a biasing current, whereby the diode path is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, said bias voltage source comprising a source of unidirectional current in series with the plate circuit of a pentode having a cathode resistor, the control grid of said pentode being returned to a point on said cathode resistor, and a frequency selective circuit associated with said diodes, whereby said cut-off amplitudes are caused to vary with the signal frequency.

10. A noise limiting circuit in accordance with claim 9, characterized in that a source of unidirectional voltage is inserted between said grid and said cathode resistor, there being means provided to vary the magnitude of said voltage in accordance with the amplitude of the desired signal.

11. A noise limiting circuit having high and low potential input and output terminals, connections between said low potential input and output terminals, a pair of serially connected, mutually reversed diodes connected between said high potential input and output terminals, a voltage source for supplying said diodes with a biasing current, said biasing voltage source being connected between the low potential side of said circuit and the junction between said diodes, whereby the diode path is rendered substantially non-conducting for signals exceeding predetermined cut-off amplitudes, a series frequency selective circuit comprising a resistor and a capacitor connected across said output terminals, and a second series frequency selective circuit comprising a resistor and an inductor connected across said input terminals, said resistors, capacitor and inductor being so related that said limiting circuit presents a substantially constant resistance over a wide band of frequencies, while simultaneously having a cut-off level which varies inversely with frequency.

12. A noise limiting circuit in accordance with claim 11, including means independent of at least one of said frequency selective circuits for completing the direct current circuit for said biasing current.

13. In a noise limiting circuit, a constant current source, a pair of diodes, a first impedance for connecting one of said diodes in shunt with said constant current source, a second impedance for connecting the other of said diodes in shunt with said constant current source, a source of signals connected to one of said impedances, and a signal utilization means connected to the other of said impedances.

14. In an amplitude limiting circuit, a vacuum tube having at least a cathode, a grid, and an anode, an impedance having one end connected to said cathode, a source of substantially constant voltage having one terminal thereof connected to the other end of said impedance, a connection between said grid and a point on said impedance, said vacuum tube, impedance, and voltage source constituting a source of substantially constant current, a pair of diodes, an impedance connecting one of said diodes in shunt with said constant current source, another impedance connecting the other of said diodes in shunt with said constant current source, a source of signals connected to one of said last-mentioned impedances, and a signal utilization means connected to the other of the said impedances.

15. In an amplitude limiting circuit, a vacuum tube having at least a cathode, a grid, and an anode, an impedance having one end connected to said cathode, a source of substantially constant voltage having one terminal thereof connected to the other end of said impedance, a connection between said grid and a point on said impedance, said vacuum tube, impedance, and voltage source constituting a source of substan-

tially constant current, a pair of diodes, an impedance connecting one of said diodes in shunt with said constant current source, another impedance connecting the other of said diodes in shunt with said constant current source, a source of signals connected to one of said last-mentioned impedances, a signal utilization means connected to the other of the said impedances, and a frequency selective network associated with at least one of said diodes, whereby the cut-off amplitude of said circuit is caused to vary in accordance with the frequency of the signals derived from said source.

16. A noise limiting circuit, comprising a source of signals and a utilization means therefor, signal transfer means therebetween including a serially connected non-linear impedance, means for passing a biasing current through said non-linear impedance, whereby said transfer means is rendered substantially non-conducting for signals exceeding a predetermined cut-off amplitude, said biasing current being interrupted only in the presence of noise signals exceeding said cut-off amplitude, and frequency selective circuits operatively associated with said non-linear impedance for varying said cut-off amplitude as a function of the signal frequency.

17. A noise limiting circuit, comprising a source of signals and a signal utilization means therefor, signal transfer means therebetween including a device for limiting the amplitude of transferred signals to a predetermined cut-off amplitude, the gain and band width of said signal transfer means being substantially unaffected by said amplitude limiting device, and frequency responsive means operatively associated with said device for varying said cut-off amplitude in accordance with a predetermined function of the signal frequency.

18. A noise limiting circuit, comprising a source of signals and a signal utilization means therefor, signal transfer means therebetween including a device for limiting the amplitude of transferred signals to a predetermined cut-off amplitude, the gain and band width of said signal transfer means being substantially unaffected by said amplitude limiting device, and frequency responsive means operatively associated with said device for varying said cut-off amplitude in accordance with an inverse function of the signal frequency.

19. A noise limiting circuit according to claim 18, characterized in the provision of means for limiting both the positive and negative alternations of the signal to substantially the same amplitudes.

20. In a signaling system, a signal channel adapted to transfer desired signals, an amplitude-limiting device in said channel, means for rendering said device conductive only to signals whose amplitude does not exceed a predetermined cut-off amplitude, whereby said device becomes substantially non-conducting for signals whose amplitude exceeds said cut-off amplitude, and frequency responsive means operatively associated with said device for varying said cut-off amplitude as a function of the signal frequency.

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