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NOISE-LIMITING CIRCUITS FOR CARRIER WAVE COMMUNICATION SYSTEMS

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Fig. 1.

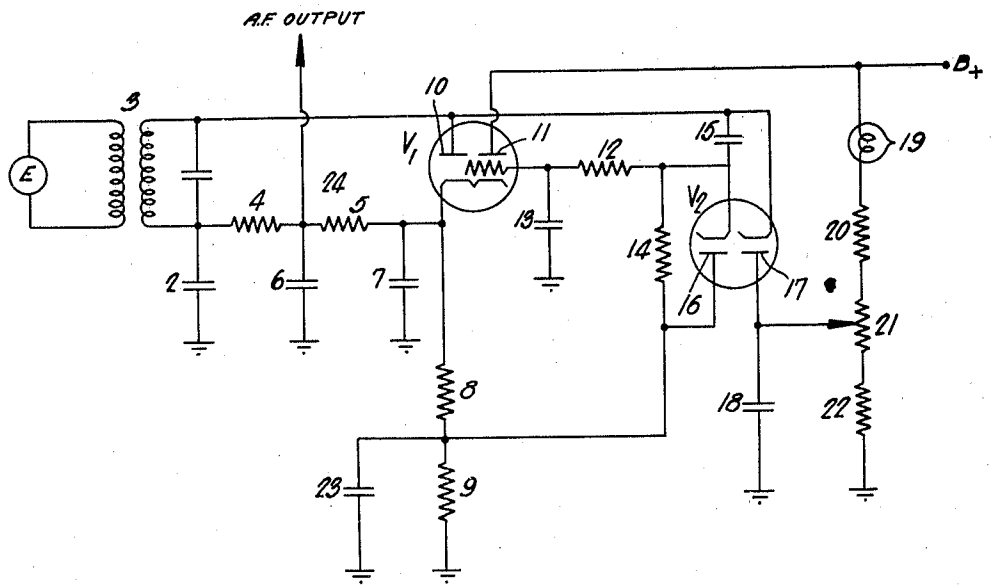
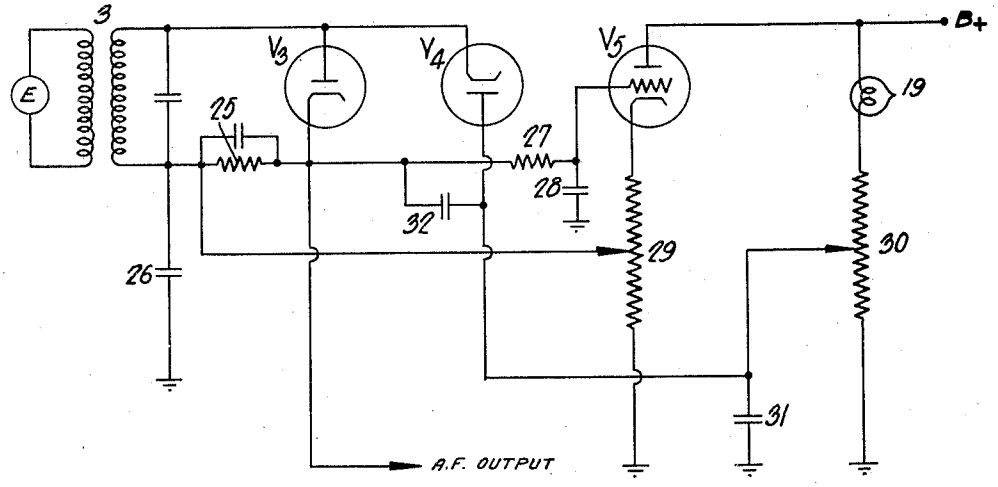


Fig. 2.



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NOISE-LIMITING CIRCUITS FOR CARRIER WAVE COMMUNICATION SYSTEMS

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10 Claims. (Cl. 250—20)

This invention relates to noise limiting circuits and more particularly to novel means for limiting the amplitude of interfering noise pulses or signals in carrier wave communication systems and the like.

One of the objects of this invention is to provide an amplitude limiting circuit which will limit the amplitude of noise pulses and the like to a predetermined relative level.

Another object of the invention is to provide a carrier wave demodulating circuit, the noise output of which is automatically limited to substantially that of the peak desired signal regardless of changes in the strength of the carrier wave.

A further object of the invention is to provide in an automatic noise limiting circuit a means for maintaining efficient limiting action regardless of varying supply voltages.

The invention employs non-linear impedance means having variable polarizing or biasing arrangements of such a nature that a transmission path including these means acts to discriminate against all noise pulses which exceed some predetermined multiple of the carrier level, and, due to certain automatic features, these means are maintained at a high efficiency at all times in spite of changes in the strength of the received carrier. Such a discriminating means is particularly desirable when the desired signals are relatively weak or when the carrier level varies markedly, and where there is a background of sharp, high-amplitude noise pulses such as those occasioned by atmospherics, automotive ignition systems, domestic and industrial electrical equipment, and the like.

More particularly, by the present invention, there is provided in an electrical wave transmission system which includes a source of combined modulated carrier signals and interfering noise signals, a first non-linear impedance means for demodulating carrier signals, a second non-linear impedance means in shunt with said first non-linear impedance means but having its elements reversed relative to those of said first mentioned means, biasing means for applying a polarizing or delay voltage to said second non-linear impedance means whereby said means cannot rectify said combined signal until such signal exceeds a certain amplitude, a common load for said first and second non-linear impedance means whereby the rectification products of the relatively reversed non-linear impedance means tend mutually to cancel one another, carrier signal amplitude responsive means for varying said polarizing voltage in accordance with the average value of said carrier signal whereby said second non-linear impedance means is enabled to rectify only those combined signal voltages which exceed a predetermined level relative to the carrier signal, and means for deriving a relatively noise-free demodulated signal from said common load.

The invention may be clearly understood by reference to the accompanying drawing, in which:

Fig. 1 is a schematic diagram illustrating a preferred form of the invention; and

Fig. 2 is a similar diagram illustrating a modification.

In Fig. 1, E represents a source of modulated carrier signals which may be accompanied by noise signals. Under conditions of no noise, the modulated carrier is rectified or detected by means of a non-linear circuit element such as the diode section **10** of a space discharge device V_1. The diode load may be provided by the resistors **4** and **5** and the associated condensers or by a suitable equivalent. The demodulated signal may be derived from this load, as by tapping off from the junction **24** between the resistors **4** and **5**.

Connected in shunt with the diode section **10**, but having its elements in reversed relation thereto, is another non-linear circuit element such as the diode section **17** of the space discharge device V_2. Both diode sections have the resistors **4** and **5** and associated condensers as a common load and when both diodes are demodulating, the effect is to tend to reduce the demodulated signal at **24** to zero. In order to prevent this effect of the diode **17** on desired signals, means are provided for applying a polarizing or delay voltage to the second non-linear impedance, the magnitude of which varies in accordance with the average amplitude of the modulated carrier signal. Thus, in this instance a triode section **11** and the cathode resistors **8** and **9** may be provided whereby the voltage drop in these resistors may be inserted in circuit with the diode **17** to delay the action thereof. It is to be understood that the delay herein primarily referred to is a voltage delay and not a time delay. It will be observed that the voltage drop across the serially connected resistors **8** and **9**, which results from their position in the plate circuit of the triode **11**, is applied to the cathode of the diode **17** by way of the resistors **5**, **4**, and the secondary of the transformer **3**. The application of this voltage to the cathode of diode **17**

will tend, in the absence of noise signals, to maintain said cathode positive with respect to its associated anode, thereby preventing rectification of the modulated carrier signal by the diode 17. Signal or noise peaks whose amplitude exceeds a predetermined level, depending upon the voltage drop across resistors 8 and 9 and other adjustments hereinafter described, will act to drive the cathode of diode 17 negative with respect to its anode, thereby permitting signal rectification by both the diodes 10 and 17. Since the actions of the two diodes are mutually in opposition, the tendency will be greatly to reduce the rectified signal voltage obtainable from the common diode load 4—5.

The circuit as so far described would provide optimum limiting action only for desired signals having a specific predetermined average carrier level. In order that the level at which the diode 17 begins to rectify may be caused to vary in accordance with changes in the carrier amplitude of the desired carrier signal, there may be provided a signal responsive means for varying the space current in the triode 11, and hence the delay or polarizing voltage across the resistors 8 and 9. Therefore, an auxiliary diode 16 and associated circuit elements functioning as a signal rectifier or peak detector, may be so disposed that, as the carrier signal increases in average amplitude, the grid of the triode 11 will become increasingly positive, thereby increasing the triode space current and hence the delay voltage. Accordingly, the delay voltage is automatically varied so as to permit functioning of the diode 17 only for those noise voltages which exceed a predetermined level relative to the carrier signal. Preferably, the circuit constants are adjusted so as to bring the reversed diode 17 into action for all signals which exceed a maximum desired modulation level, and thus the demodulated signal at 24 will be limited to that relative modulation level.

If desired, the delay voltage applied to the diode 17 may be supplied in part by a substantially constant external source. Thus, in the figure a part of the voltage drop in the voltage divider 20—21—22 is included with that across the resistors 8 and 9. By means of the adjustable potentiometer 21, the delay voltage may be initially adjusted to give a desired operating characteristic. This adjustment is particularly important in determining the limiting threshold for small signals and may be referred to as the "small signal adjustment." Where such adjustment is subject to disturbances, due to variations in the primary supply voltage B+, a non-linear element, such as the small tungsten lamp 19, may be associated with the divider circuit so as to maintain a substantially constant current flow therein notwithstanding variations in the primary supply voltage. It will be understood that the stabilizing effect of the lamp is due to the fact that an increase in current through the divider is accompanied by an increase in the resistance of the tungsten filament which in turn opposes the said increase in current.

Returning now to some of the circuit details, it will be noted that the triode grid is self-biased by connecting the grid return, through the resistors 12 and 14, to the junction of the serially connected resistors 8 and 9. The relative level at which limiting occurs, particularly in the case of large signals, may be fixed by adjusting the magnitudes and ratio of the resistors 8 and 9. This adjustment may be termed the "large signal adjustment" and it will be understood that its effect is to determine the portion of the plate current characteristic over which the triode 11 will be operated. The resistance-condenser combination 12—13 may be utilized to prevent the transfer of R. F. and A. F. fluctuations or signals to the triode grid. The condenser 15 serves as a means for coupling the diode 16 to the signal source E, while constituting an open circuit to the D. C. component. The magnitude of this capacity is dictated by the results which are desired. Thus, if the bias to be supplied the grid of the triode 11 from the rectifier section 16 of V_2 is to be a function largely of the average carrier amplitude, then the condenser 15 should be so selected that it passes the carrier frequency, but not the low or audio frequency demodulation products. On the other hand, if this bias is to be a function of both the average carrier amplitude and the percentage of modulation, then the condenser 15 should pass the modulation frequencies as well as carrier frequency. Preferably, however, the condenser should be sufficiently small, i. e., a high impedance to audio frequencies, so that the demodulation capabilities of the diode 10 are not deleteriously affected by the shunting effect of the diode 16 and its associated elements.

While the diode 17, as has been pointed out hereinbefore, tends to prevent the appearance of a demodulated signal across the condenser 6 when the combined signal amplitude exceeds a certain level, there is another effect which assists in the complete cancellation of the demodulated signal. This effect results from the fact that for audio frequencies the currents generated by the two diodes 10 and 17 are in opposition and each diode is effectively an audio frequency short circuit upon the other. The effective radio frequency input impedance of the combination of the two diodes is correspondingly very low, and only a very small portion of the input radio frequency voltage can build up across the input, unless the source of radio frequency signal is itself of very low impedance. This latter is not the case in the usual radio receiver where the impedance of the source is the impedance of the tuned input circuit, which is usually of the order of magnitude of several hundred thousand ohms.

Although Fig. 1 illustrates a preferred embodiment of the improved noise limiting circuit, the invention is by no means limited thereto, for the circuit is capable of various modifications. For example, the circuit may be simplified by omitting entirely the diode section 16 of the device V_2. Thus, in Fig. 2 only two diodes are employed, V_3 and V_4, corresponding respectively to the diode sections 10 and 17 of Fig. 1. The triode V_5 corresponds to the triode section 11 of Fig. 1. A voltage which becomes more positive with increasing carrier level is derived from the cathode end of the diode load 25 and is applied by way of the resistance condenser filter 27—28 to the grid of the triode V_5. A substantially constant voltage is inserted in the D. C. circuit of the diode V_4 by means of the potentiometer 30, in series with which there may be inserted the non-linear device 19 as explained hereinbefore. A delay voltage which is a function of the average carrier amplitude is here inserted in the D. C. circuit of the diode V_4 by means of the tap on the potentiometer 29, thus maintaining the correct relative level at

which optimum limiting action obtains, regardless of the actual carrier level.

In the above, frequent references have been made to non-linear impedance means, and more specifically to diodes. These may, if desired, be replaced by any other suitable means such as dry disc rectifiers, chemical or mineral rectifiers, or the like. Considerable variation also is possible, as will be seen by those skilled in the art, in the particular forms of the several load circuits and in the means for deriving, supplying and/or filtering the delay voltages.

It will be apparent that further modifications of the invention are possible without departing from the scope of the invention.

I claim:

1. In an electrical wave transmission system, a source of modulated carrier signals, a first non-linear impedance means for demodulating said carrier signals, a second non-linear impedance means connected in shunt with said first means and in reversed relation thereto, biasing means for applying a polarizing voltage to said second non-linear impedance means, carrier signal amplitude responsive means for varying said polarizing voltage in accordance with the average value of said carrier signal, a common load for said first and second non-linear impedance means, means for deriving a demodulated signal from said common load, a source of direct current voltage which may be subject to variations in magnitude, a voltage divider connected across said last-named source, said voltage divider including a resistance device whose resistance varies with the current therethrough in such manner that the voltage drop across at least a part of said divider remains substantially unaffected by the said variations in said source, and connections for applying the voltage existing across at least a part of said divider to said second non-linear impedance means in addition to said polarizing or bias voltage.

2. In an electrical wave transmission system which includes a source of combined modulated carrier signals and interfering noise signals, a first diode space discharge means for demodulating carrier signals, a second diode space discharge means connected in shunt with said first diode means to receive signals from said source but having its elements reversed relative to those of said first diode, biasing means for applying a polarizing voltage to said second diode, thus preventing said second diode from rectifying said combined signal until such signal exceeds a certain amplitude, a common load impedance for said first and second diode means whereby the rectification products of the relatively reversed diodes tend mutually to cancel one another, means for varying said polarizing voltage, said last-named means including a space discharge tube having at least a cathode, an anode, and a control grid, means including a diode rectifier for varying the bias on said control grid in response to variations in the average carrier amplitude, whereby said second diode means is enabled to rectify only those voltages which exceed a predetermined level relative to the carrier signal, and means for deriving a demodulated signal from said common load.

3. In an electrical wave transmission system which includes a source of combined modulated carrier signals and interfering noise signals, a first diode for rectifying carrier signals, a second diode connected in shunt with said first diode to receive signals from said source but having its electrodes reversed relative to those of said first diode, biasing means for applying a polarizing voltage to said second diode, whereby said second diode can rectify said combined signal only when said signal exceeds a certain amplitude determined by said polarizing voltage, a load impedance which is common to said first and second diodes, whereby the rectification products of the relatively reversed diodes tend mutually to cancel each other, means for varying said polarizing voltage, said last-named means including a vacuum tube having at least a cathode, an anode, and a control grid, an auxiliary diode rectifier arranged to receive the carrier signal and having a load impedance, and means for connecting said last-mentioned load impedance between said control grid and said cathode, whereby the bias on said control grid is varied in response to variations in the average carrier amplitude and said second diode means is enabled to rectify only those voltages which exceed a predetermined level relative to the average carrier signal amplitude.

4. In a noise reduction system for carrier wave reception, a pair of shunt-connected diodes with their elements mutually reversed, a connection between the anode of the first of said diodes and the cathode of the second of said diodes, a load circuit connected between the anode and cathode of said first diode, a source of modulated carrier signals, means for applying signals from said source to the elements of said diodes, a vacuum tube having at least a cathode, an anode, and a control grid, the cathode of said first diode and the cathode of said vacuum tube being connected together, a first impedance in the cathode circuit of said vacuum tube, a connection between the cathode of said first diode and the anode of said second diode, said last-named connection including said first impedance, a second impedance, means for developing across said second impedance a unidirectional voltage which is proportional to the average amplitude of said carrier signal, and means including an electrical filter for connecting said second impedance between said grid and a point on said first impedance, whereby the voltage developed across said second impedance varies the space current in said vacuum tube in accordance with the average amplitude of said carrier signals.

5. In a noise reduction system for carrier wave reception, a pair of shunt-connected diodes with their elements mutually reversed, a connection between the anode of the first of said diodes and the cathode of the second of said diodes, a load circuit connected between anode and cathode of said first diode, a source of modulated carrier signals, means for applying signals from said source to the elements of said diodes, a vacuum tube having at least a cathode, an anode, and a control grid, the cathode of said first diode and the cathode of said vacuum tube being connected together, a first impedance in the cathode circuit of said vacuum tube, a connection between the cathode of said first diode and the anode of said second diode, said last-named connection including said first impedance and a source of voltage of adjustable magnitude, whereby said second diode becomes operative only for signals exceeding a certain magnitude which is determined by the sum of the voltage of said last-mentioned source and the voltage across said first impedance, a second impedance, means for developing across said second impedance a unidirectional voltage which is proportional to the

average amplitude of said carrier signal, and means including an electrical filter for connecting said second impedance between said grid and a point on said first impedance, whereby the voltage developed across said second impedance varies the space current in said vacuum tube in accordance with the average amplitude of said carrier signals.

6. In a noise reduction system as claimed in claim 5, a resistance element having a non-linear voltage-current characteristic, said resistance element being so associated with said source of voltage of adjustable magnitude that undesired voltage variations in said source are substantially prevented.

7. In a noise reduction system for carrier wave reception, a pair of shunt-connected diodes with their elements mutually reversed, a connection between the anode of the first of said diodes and the cathode of the second of said diodes, a load circuit connected between anode and cathode of said first diode, a source of modulated carrier signals, means for applying signals from said source to the elements of said diodes, a vacuum tube having at least a cathode, an anode, and a control grid, means including a low pass filter for connecting the cathode of said first diode with said control grid, an impedance in the cathode circuit of said vacuum tube, a connection between the anode end of said load circuit and a point on said cathode circuit impedance, and connections between the anode of said second diode and the low potential end of said cathode circuit impedance, whereby the voltage across at least a part of said cathode circuit impedance is applied between the elements of said second diode as a polarizing voltage.

8. In a noise reduction system for carrier wave reception, a pair of shunt-connected diodes with their elements mutually reversed, a connection between the anode of the first of said diodes and the cathode of the second of said diodes, a load circuit connected between the anode and cathode of said first diode, a source of modulated carrier signals, means for applying signals from said source to the elements of said diodes, a vacuum tube having at least a cathode, an anode, and a control grid, means including a low pass filter for connecting the cathode of said first diode with said control grid, an impedance in the cathode circuit of said vacuum tube, a connection between the anode end of said load circuit and a point on said cathode circuit impedance, and connections including a source of voltage of adjustable magnitude between the anode of said second diode and the low potential end of said cathode circuit impedance, whereby said second diode becomes operative only for signals exceeding a certain magnitude determined by the voltage of said last-mentioned source and the voltage across said cathode circuit impedance.

9. In a noise reduction system as claimed in claim 8, a resistance element having a non-linear voltage-current characteristic, said resistance element being so associated with said source of voltage of adjustable magnitude that undesired voltage variations in said source are substantially prevented.

10. In an electrical wave transmission system, a source of carrier signals, a first rectifier for demodulating said carrier signals, a second rectifier connected in shunt with said first rectifier and in reverse relation thereto to receive signals from said source, a common load for said first and second rectifiers, a space discharge device having at least a cathode, an anode and a control electrode, a space current circuit for said device, an impedance connected in said space current circuit, whereby a voltage whose magnitude is dependent on the magnitude of the space current is established across said impedance, means for utilizing said voltage to bias said second rectifier so as to prevent operation thereof for signals whose magnitude does not exceed the bias, and means for varying the potential of said control electrode in dependence upon the carrier signal amplitude, whereby the said space current is varied to vary the bias voltage and thus maintain the amplitude of said voltage in predetermined relation to the carrier signal amplitude.

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