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WAVE-SIGNAL AMPLITUDE-LIMITING SYSTEM

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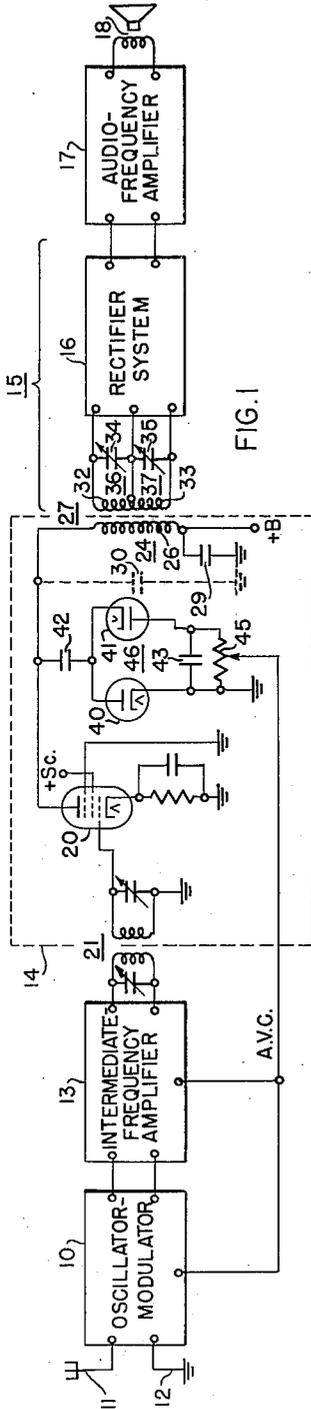


FIG. 1

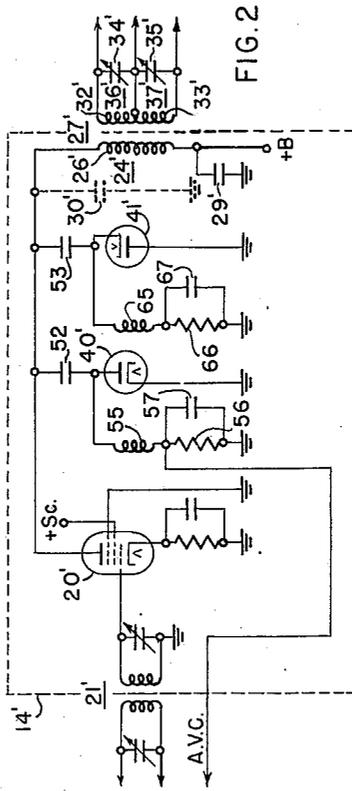


FIG. 2

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WAVE-SIGNAL AMPLITUDE-LIMITING SYSTEM

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9 Claims. (Cl. 178-44)

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This invention relates to wave-signal amplitude-limiting systems and, particularly, to wave-signal amplitude-limiting systems which provide a limiting level that varies with the average amplitude of a wave signal applied to the system. Although the invention is not limited thereto, it has particular utility as a limiting system in a frequency-modulation wave-signal receiver and will be described in that connection.

Amplitude-limiting systems are frequently employed in frequency-modulation wave-signal receivers to reduce noise disturbances and distortion which otherwise may appear in the output circuit of the receiver due to undesired amplitude variations of the translated frequency-modulated wave signal. Some of these limiting systems perform their amplitude-limiting action only when the amplitude of the applied wave signal exceeds a predetermined fixed level. Accordingly such systems are ineffective to remove undesired amplitude modulation from a wave signal having amplitude values which are less than the above-mentioned predetermined level. Other limiting systems heretofore proposed are effective to provide a limiting level which varies with the average amplitude of the applied wave signal and therefore are able to remove to a considerable extent undesired amplitude variations appearing in the applied wave signal at both the lower amplitude and higher amplitude levels, thus ensuring less noise disturbance and distortion in the output signal of a frequency-modulation receiver employing such a limiting system. A system of the last-mentioned type is disclosed in the copending application of Harold A. Wheeler, Serial No. 693,268, filed August 27, 1946, entitled "Wave-signal amplitude-limiting system," and assigned to the same assignee as the present invention.

The limiting system disclosed in the above-mentioned copending application employs a series circuit including a rectifier device and a resistor-condenser network which is coupled effectively in parallel with a high-efficiency or high-Q parallel-resonant circuit resonant at the mean frequency of the frequency-modulated wave signals applied thereto. As is well known, the "Q" of a resonant circuit is conveniently defined as the ratio of its inductive reactance to resistance. Peak rectification of the half cycles of but a single polarity of the applied wave signal takes place in the described series circuit due to the unidirectional conductivity characteristic of the rectifier device. The resistor in this series circuit, by loading the rectifier device, provides a

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substantial part of the total damping of the resonant circuit. This damping reduces the magnitude of the wave-signal potentials developed across the resonant circuit and thereby limits the amplitude of the wave signal at a level established by the average-amplitude value of the applied wave signal. Since the rectifier device of this arrangement provides a damping action only during the interval when it is conductive, the instantaneous damping action takes place primarily on alternate half cycles of the wave signal. Consequently, the rectifier device may be considered effectively to control the peak amplitudes, and hence the limiting level of the wave signal, for only those alternate half cycles of the proper polarity to render the rectifier device conductive. The resonant circuit, however, tends to integrate this damping action over a complete cycle of the wave signal to an extent which is proportional to the magnitude of the Q of the resonant circuit. For best limiting operation with such a system, therefore, it is desirable to employ a resonant circuit having a high Q. For some applications, however, certain considerations such as space and cost may make it desirable to employ resonant circuits which do not have a high Q.

The type of limiting action afforded by a system of the type disclosed in the above-mentioned application, while diminishing considerably the effect of undesired amplitude modulation in the frequency-modulated wave signals which are translated by the limiting system, does not quite assure the greatest possible reduction in unwanted amplitude modulation. It is well known that in most cases the limiting of the amplitude of a wave signal results in the production of numerous harmonic-frequency components in the resultant wave signal. When significant harmonic voltages are thus produced, the frequency detector which is coupled to the limiting system may respond to these harmonic voltages to the detriment of its response to the desired fundamental-frequency components. The second-harmonic components, due to their closer proximity to the fundamental-frequency components in the case of the higher order harmonic components, are most troublesome. It may, therefore, in some applications, be desirable to avoid the production of second-harmonic components in the limiting system in order to ensure that the frequency detector has better response to the fundamental-frequency components of the wave signal applied thereto. All harmonic components, and particularly the un-

wanted second-harmonic components, are more pronounced when the Q of the parallel-resonant circuit associated with the limiting system is not high. This may be a disadvantage for those applications wherein it is desirable to employ in association with the type of limiting system last described a resonant circuit which does not have a high Q .

It is an object of the present invention, therefore, to provide a new and improved wave-signal amplitude-limiting system having improved limiting characteristics particularly when used in association with a resonant circuit of relatively low Q .

It is another object of the invention to provide a new and improved wave-signal amplitude-limiting system which is effective to reduce the amplitudes of certain of the more troublesome harmonic-frequency components of the wave signals translated by the limiting system.

It is a further object of the invention to provide a new and improved wave-signal amplitude-limiting system which tends to eliminate the second and other even-order harmonic-frequency components which might otherwise appear in the wave signal translated by the limiting system.

It is another object of the invention to provide a new and improved wave-signal amplitude-limiting system of the variable-threshold type which automatically establishes a limiting level in accordance with the average amplitude of the frequency-modulated wave signal applied thereto and one which affords improved rejection of undesired amplitude modulation.

In accordance with a particular form of the invention, a system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprises a frequency-modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of the channel and having much less than critical damping. The system also includes a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of the rectifier devices and effectively including at least one of the condensers. Each of the series circuits is coupled effectively in parallel with the resonant circuit with the conductive direction of one of the series circuits opposite to that of the other, and each of the series circuits has in the conductive direction thereof at the aforesaid frequency an impedance much less than the impedance of the resonant circuit. The amplitude-limiting system includes at least one resistor effectively connected in parallel with at least one of the condensers and having a value of resistance much greater than the conductive-direction impedance of either of the series circuits to effect peak rectification of each wave-signal half cycle. However, this value is sufficiently small relative to the resonant-circuit impedance to cause by loading the rectifier devices an average conductance providing a substantial part of the total damping of the resonant circuit but much less than critical damping thereof. The condenser of each of the parallel-connected condensers and resistors has a value to provide with the resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by the channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias poten-

tial developed across each parallel-connected condenser and resistor by rectification varies with the average amplitude of the translated wave signal to vary the amplitude level about which amplitude modulation is removed.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring now to the drawing, Fig. 1 is a circuit diagram, partly schematic, of a complete frequency-modulation wave-signal receiver which includes a wave-signal amplitude-limiting system embodying the present invention in a particular form; and Fig. 2 is a circuit diagram of a wave-signal amplitude-limiting system embodying the present invention in a modified form.

Referring now more particularly to Fig. 1 of the drawing, there is represented a complete frequency-modulation wave-signal receiver of somewhat conventional design which utilizes an amplitude-limiting system embodying one form of the present invention. In general, the receiver includes an oscillator-modulator 10 having an input circuit coupled to an antenna system 11, 12 and having an output circuit coupled to an intermediate-frequency amplifier 13 of one or more stages. Connected in cascade with the amplifier 13, in the order named, are a wave-signal amplitude-limiting system 14, more fully to be described hereinafter, a frequency detector 15 including a rectifier system 16, an audio-frequency amplifier 17 of one or more stages, and a sound reproducer 18. The frequency detector 15 is preferably one having a linear frequency-response characteristic and may be of the type having side-tuned resonant input circuits as represented in Fig. 1.

An automatic-amplification-control or A. V. C. bias which is developed in unit 14 is applied in a conventional manner through a circuit designated as A. V. C. to the input circuits of one or more tubes of the oscillator-modulator 10 and the intermediate-frequency amplifier 13.

It will be understood that the various units just described may, with the exception of the wave-signal limiting system 14, be of conventional construction and operation, the details of which are well known in the art rendering further detailed description thereof unnecessary. Considering briefly the operation of the receiver as a whole, and neglecting for the moment the detailed operation of the wave-signal amplitude-limiting system 14 presently to be described, a desired frequency-modulated wave signal is selectively received and converted to a frequency-modulated intermediate-frequency wave signal in the oscillator-modulator 10, amplified in the intermediate-frequency amplifier 13, further amplified and limited in unit 14 to a limiting level varying in accordance with the average amplitude of the intermediate-frequency wave signal, and detected by the frequency detector 15, thereby to derive the audio-frequency modulation components thereof. The audio-frequency modulation components are, in turn, amplified in the audio-frequency amplifier 17 and are reproduced by the sound reproducer 18 in a conventional manner. The A. V. C. bias developed in unit 14 is effective to control the amplification of one or more of the units 10 and 13 to maintain the signal input to unit 14 within a rela-

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tively narrow range for a wide range of received signal intensities.

Referring now more particularly to the portion of the receiver embodying the present invention, the wave-signal amplitude-limiting system 14 comprises a wave-signal translating channel which conveniently includes one of the intermediate-frequency amplifier stages of the receiver. This channel is shown as including one such stage comprising a conventional vacuum-tube repeater 20 having a tuned input circuit which is connected through a transformer 21 to the tuned output circuit of the intermediate-frequency amplifier 13. The output circuit of the repeater 20 includes a parallel-resonant circuit 24 which is substantially resonant at the center frequency of the pass band of the intermediate-frequency channel and which has much less than critical damping. The parallel-resonant circuit 24 includes the primary winding 26 of a transformer 27, one terminal of the winding being connected to the anode of the repeater 20 while the other terminal is connected to a source of potential indicated as +B and to ground through an intermediate-frequency bypass condenser 29. The parallel-resonant circuit 24 also includes in shunt to the winding 26 a condenser 30, shown in broken lines since it may be comprised in whole or in part of the inherent interelectrode and output-circuit capacitance of the repeater 20 and the capacitances of the rectifier devices 40 and 41 to be described in detail hereinafter. Transformer 27 includes two secondary windings 32 and 33 which are tuned by condensers 34 and 35, respectively, to opposite sides of the center frequency of the intermediate-frequency wave-signal translating channel, thus forming two side-tuned resonant circuits 36 and 37. These tuned circuits are, in turn, coupled to individual rectifier circuits to provide a conventional side-tuned frequency detector 15.

The limiting system also includes a pair of rectifier devices 40 and 41, preferably low-impedance thermionic diodes, and at least one pair of condensers 42, 43. The rectifier devices are connected to provide two series circuits each including an individual one of the rectifier devices and effectively including at least one of the condensers last mentioned. The anode of the rectifier device 40 is connected directly to the cathode of the device 41 while the grounded cathode of the former is connected to the anode of the last-mentioned rectifier device through the condenser 43. Condenser 43 has a relatively large value of capacitance. The condenser 42, which has a smaller value of capacitance than that of the condenser 43, is connected between the anodes of tubes 40 and 20. It will be seen, therefore, that in the particular arrangement shown the pair of rectifier devices and the pair of condensers form two series circuits, one circuit comprising the condenser 42 and the rectifier 40 while the other includes the rectifier device 41 and both of the condensers 42 and 43. It will also be manifest that each of the described series circuits is coupled effectively in parallel with the resonant circuit 24 with the conductive direction of one of the series circuits opposite to that of the other. In accordance with the present invention, the circuit parameters of the limiting system are selected that the series circuits have in their conductive directions at the center frequency of the pass band of the intermediate-frequency channel an

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impedance much less than the impedance of the resonant circuit.

The amplitude-limiting system also includes at least one resistor effectively connected in parallel with at least one of the condensers in the above-mentioned series circuits and having a value of resistance much greater than the conductive-direction impedance of either of the described series circuits to effect peak rectification of each wave-signal half cycle. This element comprises a resistor 45 which is connected in parallel with the relatively large-capacitance condenser 43. Alternatively the resistor 45 may comprise two portions preferably having equal values, each portion being connected in parallel with an individual one of the rectifier devices 40 and 41 and thus effectively in parallel with the condenser 43. The value of the resistor 45, while being greater than the conductive-direction impedance of either series circuit, is sufficiently small relative to the impedance of the resonant circuit 24 to cause by loading the rectifier devices 40 and 41 and average conductance which provides a substantial portion of the total damping of the resonant circuit but much less than critical damping thereof.

The condenser of each of the parallel-connected condensers and resistors, namely the condenser 43 since there is only one such combination in the described rectifier arrangement, has a value to provide with the resistor 45 in parallel therewith a time constant which is greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by the intermediate-frequency channel. For this value of the condenser or condensers, the bias potential developed across each such parallel-connected resistor-condenser combination by peak rectification varies with the average-amplitude value of the translated wave signal to vary the limiting level of the system in accordance therewith yet has a substantially constant value for the undesired amplitude modulation to effect amplitude limiting by the system at the aforesaid level.

The described arrangement of the rectifier devices 40, 41 and condensers 42, 43 provides a voltage-doubling rectifier system in which the unidirectional voltage developed across the condenser 43 has a value equal to twice the average peak amplitude of the intermediate-frequency wave signal. Since this value of unidirectional voltage may be too large to provide correct A. V. C. action, the A. V. C. circuit may be connected as indicated to an intermediate point on the resistor 45 for supplying a portion only of the bias developed across the condenser 43 to units 10 and 13 to control the gain thereof as previously described.

Considering now the operation of the wave-signal amplitude-limiting system just described, the wave signals developed across the resonant circuit 24 are also applied to the two series circuits of the rectifier arrangement 46. Assuming first that the instantaneous polarity of the wave signal is such that the ungrounded terminal of the resonant circuit 24 is positive, the positive half cycle of the developed signal is effective to render only the device 40 conductive, thus producing an increase in the charge on the condenser 42. The unidirectional potential developed across the condenser 42 from the increased charge is substantially equal in magnitude to the positive peak value of the frequency-modulated wave signal. On the next or negative half cycle, the device 40 ceases to conduct but the rectifier de-

vice 41 then has proper polarity to be rendered conductive. There is applied at this time to the series circuit comprising the rectifier device 41 and the condenser 43 an instantaneous peak potential comprising the potential appearing across the winding 26 plus the increased potential earlier developed across the condenser 42. These potentials are in series-aiding relationship so that substantially the peak-to-peak potential of the wave signal developed across the parallel-resonant circuit 24 in a complete wave-signal cycle is applied to the rectifier device 41 and condenser 43. Condenser 43 is therefore charged to a potential value which is substantially twice that developed across the condenser 42 on the preceding half cycle, and the condenser 42 is simultaneously discharged. The described peak-to-peak rectification operation is repeated for successive wave-signal cycles.

The amount of damping afforded by the rectifier arrangement 46 is determined by the amount of energy taken from the peak portion of the wave-signal oscillation during each half cycle thereof. This is, in turn, determined by the amount of energy discharged during each cycle from the condenser 43 through the resistor 45, and the energy discharge during each cycle is controlled by the time constant of the resistor-condenser combination 45, 43. Peak-rectification action requires that the two series circuits including the rectifier devices 40 and 41 shall include no additional impedance sufficient substantially to reduce the peak current which flows through the rectifier devices 40 and 41 during their respective conductive periods. The resonant circuit 24, per se, is one of relatively small damping, so that peak rectification of each half cycle by devices 40 and 41, while providing a substantial portion of the total damping of the resonant circuit, affords much less than critical damping thereof. This damping reduces the magnitude of the wave-signal potential developed across the resonant circuit 24 and therefore affords a limiting action.

When the condenser 43 and the resistor 45 have values as mentioned above, the described loading of the rectifier devices 40 and 41 permits the amplitude of the wave-signal potentials developed across the resonant circuit 24 to rise and fall slowly with the variations of the wave-signal average amplitude. During slow variations of the wave-signal amplitude, the condenser 43 has time to charge or to discharge slowly. However, the time constant of the resistor-condenser combination 45, 43 is substantially greater than the greatest radian period of the amplitude modulation which is to be removed from the wave signal. This time constant prevents the condenser 43 from charging or discharging at as rapid a rate as the undesired amplitude modulation so that the condenser voltage acts like a fixed bias voltage for such modulation. As a result, the bias potential adjusts or varies the limiting level of the limiting system 14 in accordance with the average amplitude of the translated intermediate-frequency wave signal, yet has a substantially constant value with respect to the undesired amplitude modulation to be removed and thus effects amplitude limiting at this level in the system 14. A portion of the bias potential, when applied as an A. V. C. bias to units 10 and 13 from an intermediate potential point on the resistor 45, is effective to limit the average-amplitude variations of the wave signal applied to the limiting system 14.

As a result of the peak rectification by the rectifier arrangement 46 of each half cycle of

the signal applied to the resonant circuit 24, instead of every other half cycle as with prior limiting arrangements which employ a resonant circuit, the effective conductance which damps the parallel-resonant circuit provides a more uniform damping action. This, in turn, permits the use in the limiting system of a parallel-resonant circuit which need not have a particularly high Q. The peak-to-peak rectification afforded by the arrangement 46 produces a symmetrical conduction on both half cycles of the frequency-modulated wave signal applied to the resonant circuit 24. Rectification of both half cycles of the applied wave signal also tends to cancel out the troublesome second and other even-order harmonic components. It has been determined that a significant increase in amplitude-modulation rejection is provided by the instant system over that which is obtained with limiting systems which peak rectify only the alternate half cycles of the applied wave signal. In the higher wave-signal average-amplitude levels, this improvement may be as much as four to one.

The following circuit constants are given for an embodiment of the invention of the type represented in Fig. 1:

Resistor 45	270 kilohms
Condenser 42	100 micromicrofarads
Condenser 43	0.25 microfarad
Tube 20	Type 6AU6
Tubes 40 and 41	6AL5 (Duplex diode)
Winding 26	30 turns No. 30 D. S. C. wire close wound on 1/2" diameter winding form.
Intermediate frequency	10.7 megacycles

Referring now to Fig. 2 of the drawing, there is represented schematically a wave-signal amplitude-limiting system embodying the present invention in a modified form which is generally similar to that represented in Fig. 1, similar elements being designated by the same reference numerals primed. The output circuit of a repeater 20' includes a parallel-resonant circuit 24'. The anode of a rectifier device 40' is connected to the anode of repeater 20' through a coupling condenser 52 while the cathode of the device is connected to ground. The cathode of a rectifier device 41' is also connected to the anode of the repeater 20' through a coupling condenser 53 and the anode of this device is grounded. Rectifier device 40' has connected between the terminals thereof a series circuit comprising an intermediate-frequency choke 55 and the parallel combination of a resistor 56 and a condenser 57. The A. V. C. bias potential for stages in the wave-signal translating channel preceding the parallel-resonant circuit 24' is taken from the junction of the choke 55 and the resistor 56. The rectifier device 41' has connected between its terminals a series circuit comprising a choke 65 and a parallel resistor-condenser combination 66, 67. The network including the condenser 52, the rectifier device 40', the choke 65, the resistor 56, and the condenser 57 comprises a first series circuit while the network including the corresponding elements 53, 41', 65, 66, and 67 comprises a second series circuit, each of which includes an individual one of the rectifier devices and effectively includes at least one of the condensers 57 and 67. The described series circuits have substantially identical characteristics and are coupled in parallel with the resonant circuit 24'. Each of the described series circuits has,

in its respective conductive direction and at the center frequency of the intermediate-frequency pass band, an impedance which is much less than the impedance of the resonant circuit. In the conductive direction of the first series circuit this impedance comprises that of the condenser 52 and that of the rectifier device 40' while in the conductive direction of the second series circuit this impedance comprises that of the rectifier device 41' and that of the condenser 53. Each of the condensers 57 and 67 has a value to provide with the particular resistor in parallel therewith a time constant which is greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by the system.

The resistors 56 and 66 may be connected if desired in parallel with their corresponding rectifiers 40' and 41' instead of being connected in parallel with the condensers 57 and 67, as shown. Other variations of the limiting system represented in Fig. 2 will be manifest. For example the condensers 57 and 67 may, if desired, be omitted. In this case the condensers 52 and 53 are selected with reference to the resistors 56 and 66, in the manner previously explained in detail, to provide the required time constants. The chokes 55 and 65 may also be omitted from the last-mentioned arrangement. The resistors 56 and 66 then load the tuned circuit 24' and are effective to decrease the range of the damping effect which may be obtained with the devices 40' and 41'. When automatic volume control is desired, the connection therefor must be isolated for intermediate-frequency wave signals from the resistor 56.

The operation of the Fig. 2 amplitude-limiting system is quite similar to that of Fig. 1. Peak rectification of wave-signal half cycles of positive polarity are effected by a series circuit including the rectifier device 40' while peak rectification of wave signal half cycles of negative polarity are effected by the other series circuit including the rectifier device 41'. Thus the arrangement including the rectifier devices 40' and 41' tends to limit on individual ones of the positive and the negative peak amplitudes of the applied wave signal, as distinguished from the conjoint peak-to-peak action as in the Fig. 1 system. Otherwise the operation of the two limiting systems is essentially the same. Symmetrical limiting of the frequency-modulated wave signal which is translated by the amplitude-limiting system 14' results, and the translated signal is substantially free from undesired amplitude modulation. The entire unidirectional potential developed across the condenser 57 may be employed in the usual manner as an A. V. C. bias.

It will be apparent from the foregoing description that a wave-signal translating system embodying the present invention is effective, by substantially eliminating the second and higher order even-harmonic components from the translated wave signal and by affording a symmetrical wave-signal limiting action, to provide an output signal which is substantially free from undesired amplitude modulation. The amplitude-limiting system of the present invention has the advantage of permitting the use therein of a resonant circuit which does not require a high Q. Furthermore the amplitude-limiting system of the instant invention provides good amplitude limiting at any average-amplitude value of an applied wave signal within a substantial range of such amplitude values.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency-modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of said rectifier devices and effectively including at least one of said condensers, each of said series circuits being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and at least one resistor effectively connected in parallel with at least one of said condensers and having a value of resistance much greater said conductive-direction impedance of either of said series circuits to effect peak rectification of each wave-signal half cycle yet sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; the condenser of each of said parallel-connected condensers and resistors having a value to provide with the resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said each parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

2. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of low-impedance rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of said rectifier devices and effectively including at least one of said condensers, each of said series circuits being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and at least one resistor effectively connected in parallel with at least one of said condensers and having a value of resistance much greater than said

conductive-direction impedance of either of said series circuits to effect peak rectification of each wave-signal half cycle yet sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; the condenser of each of said parallel-connected condensers and resistors having a value to provide with the resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said each parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

3. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of said rectifier devices and effectively including at least one of said condensers, one of said condensers being common to said pair of series circuits, each of said series circuits being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and at least one resistor effectively connected in parallel with at least one of said condensers and having a value of resistance much greater than said conductive-direction impedance of either of said series circuits to effect peak rectification of each wave-signal half cycle yet sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices an average conductance providing the major part of the total damping of said resonant circuit but much less than critical damping thereof; the condenser of each of said parallel-connected condensers and resistors having a value to provide with the resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said each parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

4. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of rectifier devices and at least one pair of

condensers connected to provide two series circuits each including an individual one of said rectifier devices and effectively including at least one of said condensers, one of said condensers being common to said pair of series circuits, each of said series circuits being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and a resistor effectively connected in parallel with the other of said condensers and having a value of resistance much greater than said conductive-direction impedance of either of said series circuits to effect peak rectification of each wave-signal half cycle yet sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; said other condenser having a value to provide with said resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

5. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of said rectifier devices and effectively including at least one of said condensers, one of said condensers being common to said pair of series circuits, each of said series circuits being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; a resistor effectively connected in parallel with the other of said condensers and having a value of resistance much greater than said conductive-direction impedance of either of said series circuits to effect peak rectification of each wave-signal half cycle yet sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; said other condenser having a value to provide with said resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said parallel-connected condenser and resistor by rectification varies with the aver-

age amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed; and means connected to an intermediate potential point on said resistor for utilizing a portion of the bias potential developed across said condenser to control the gain of said channel to reduce the range of average-amplitude variations of said translated wave signal.

6. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of said rectifier devices and effectively including at least one of said condensers, each of said series circuits being capacitively coupled by at least one of said condensers effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and at least one resistor effectively connected in parallel with at least one of said condensers and having a value of resistance much greater than said conductive-direction impedance of either of said series circuits to effect peak rectification of each wave-signal half cycle yet sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; the condenser of each of said parallel-connected condensers and resistors having a value to provide with the resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said each parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

7. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency-modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of said rectifier devices and effectively including at least one of said condensers, said condensers having unequal values of capacitance and the one of said condensers of smaller capacitance being common to said pair of series circuits, each of said series circuits being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and a resistor

effectively connected in parallel with the other of said condensers and having a value of resistance much greater than said conductive-direction impedance of either of said series circuits to effect peak rectification of each wave-signal half cycle yet sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; said other condenser having a value to provide with said resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

8. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency-modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping; a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits each including an individual one of said rectifier devices and including at least one of said condensers, each of said series circuits being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and each of said series circuits having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and a pair of resistors, each effectively connected in parallel with an individual one of said condensers and having a value of resistance much greater than said conductive-direction impedance of either of said series circuits, to effect peak rectification of each wave-signal half cycle, yet the value of each of said resistors being sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices on alternate wave-signal half cycles an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; the condenser of each of said parallel-connected condensers and resistors having a value to provide with the resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said each parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

9. A system for removing the undesired amplitude modulation of a frequency-modulated wave signal comprising: a frequency-modulation wave-signal translating channel including a parallel-resonant circuit substantially resonant at the center frequency of the pass band of said channel and having much less than critical damping;

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a pair of rectifier devices and at least one pair of condensers connected to provide two series circuits having substantially identical electrical characteristics, each of said series circuits including an individual one of said rectifier devices and at least one of said condensers and being coupled effectively in parallel with said resonant circuit with the conductive direction of one of said series circuits opposite to that of the other and having in the conductive direction thereof at said frequency an impedance much less than the impedance of said resonant circuit; and a pair of resistors, each effectively connected in parallel with an individual one of said condensers and having a value of resistance which is much greater than said conductive-direction impedance of either of said series circuits, to effect identical peak rectification of each wave-signal half cycle, yet the value of each of said resistors being sufficiently small relative to said resonant-circuit impedance to cause by loading said rectifier devices on alternate wave-signal half cycles an average conductance providing a substantial part of the total damping of said resonant circuit but much less than critical damping thereof; the condenser of each of said parallel-connected con-

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densers and resistors having a value to provide with the resistor in parallel therewith a time constant both greater than the greatest radian period of the amplitude modulation to be removed from a wave signal translated by said channel and greater than the greatest radian period of the frequency modulation of the translated wave signal, whereby the bias potential developed across said each parallel-connected condenser and resistor by rectification varies with the average amplitude of said translated wave signal to vary the amplitude level about which amplitude modulation is removed.

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