July 6, 1937. W. L. CARLSON 2,085,791

HETERODYNE BEAT SIGNAL LIMITER SYSTEM

Filed Sept. 30, 1935

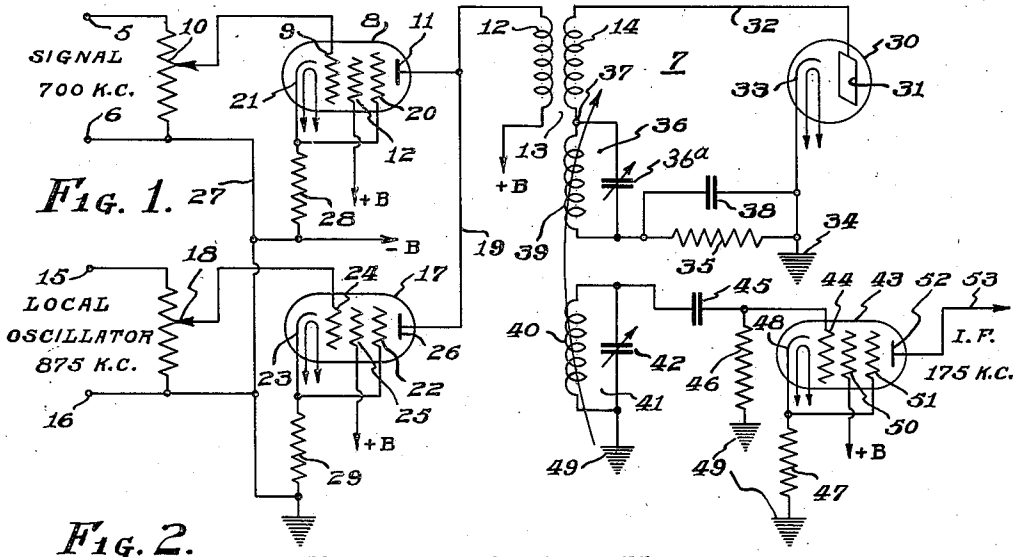


FIG. 1.

FIG. 2.

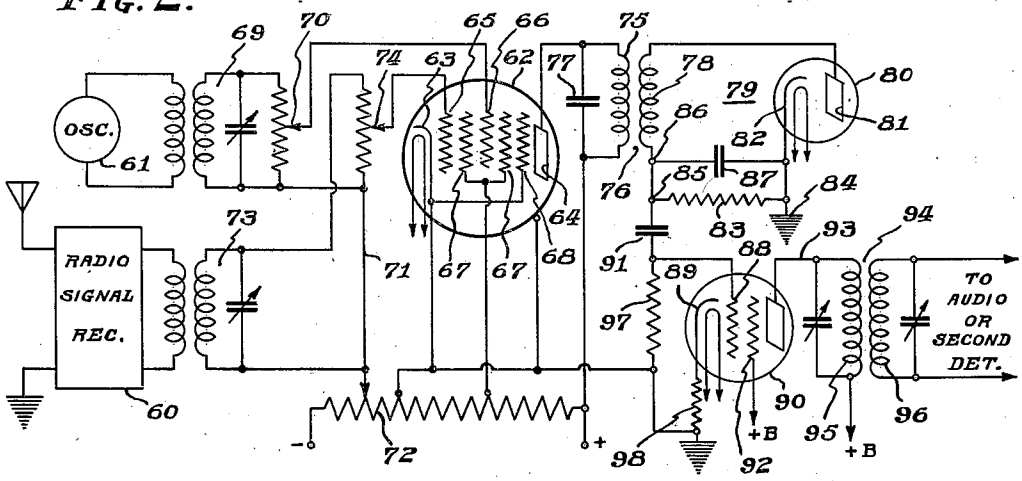
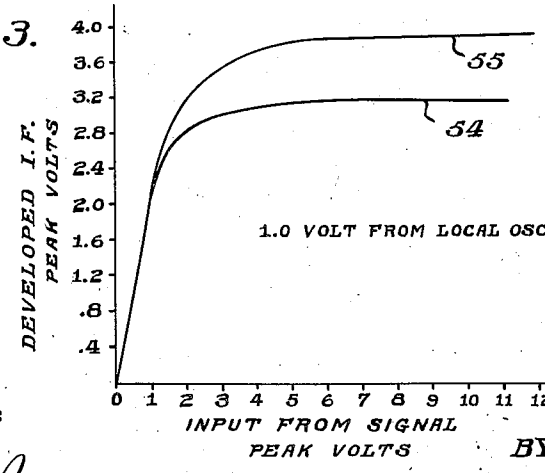


FIG. 3.



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Patented July 6, 1937

2,085,791

UNITED STATES PATENT OFFICE

2,085,791

HETERODYNE BEAT SIGNAL LIMITER SYSTEM

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Application September 30, 1935, Serial No. 42,911

12 Claims. (Cl. 250—20)

The present invention relates to radio signal receiving systems, and more particularly to a radio receiving system of the heterodyne type and has for its primary object to provide an improved signal limiter system in connection with a receiver of that character.

Limiter systems heretofore known usually employ non-linear load or saturation circuits whereby the attenuation varies with applied voltage so as to suppress peak signal amplitudes exceeding a predetermined value.

An object of the present invention is to provide a signal limiter system avoiding the necessity of saturation circuits which are often objectionable or cannot be readily designed in a particular circuit.

It is also a further object of the invention to provide a heterodyne beat signal limiter from which the intermediate frequency signal output is substantially flat or constant when the signal voltage exceeds the applied voltage from the local oscillation source.

It is a still further object of the present invention to provide a limiter system which may operate to receive amplitude modulated signals from a carrier wave approximately equal to or less than the local oscillation voltage as impressed upon the limiter, means whereby excessive signal and noise potentials are prevented from being transmitted through the receiving system.

A still further object is to provide a limiter system for receiving frequency modulated signals when the input signal as impressed upon the limiter circuit is greater than the local oscillator voltage whereby amplitude modulation is prevented from being transmitted through the receiving system.

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

In the drawing, Figure 1 is a schematic circuit diagram of a portion of a superheterodyne radio receiving system provided with noise limiter means embodying the invention,

Fig. 2 is a similar schematic circuit diagram of a super-heterodyne radio receiving system provided with a modification of the noise limiter means of Fig. 1 and also embodying the invention, and

Fig. 3 is a curve illustrating the operation of the limiter systems shown in Figs. 1 and 2.

Referring to Fig. 1, radio signals or a carrier wave applied to input terminals 5 and 6 are applied to a rectifier circuit 7 through an electric discharge amplifier device 8 having a control grid 9 connected with a volume control potentiometer 10 across the input terminal and having an output anode 11 connected to the primary 12 of a coupling transformer 13, the secondary 14 of which is included in the rectifier circuit.

The strength of the signal potential applied to the rectifier circuit 7 is controllable by the volume control potential 10. The amplifier device 8 is preferably of the screen grid pentode type having a screen grid 12 which effectively isolates the signal input circuit from the output anode circuit including the primary winding 12 thereby isolating the signal input circuit from the rectifier circuit.

Local oscillator signals for producing a heterodyne beat with incoming signals applied to input terminals indicated at 15 and 16 are amplified in a similar amplifier electric discharge device 17 provided with a volume control input potentiometer 18 and coupled to the rectifier circuit 7 through an output anode connection 19 with the primary winding 12 of the coupling transformer. As will be seen, the amplifier 17 for the oscillator signals is also of the screen grid type whereby the oscillator input circuit is effectively electrically isolated from the rectifier circuit. In order that a relatively strong signal may be applied to the coupling winding 12 with a relatively wide range of control of the volume level by the potentiometers 10 and 18, the amplifier devices 8 and 17 are preferably further of the pentode type, as shown, having a suppressor grid 20 connected with the cathode 21, as shown, in connection with the device 8. The device 17 is similarly provided with a suppressor grid 22, a cathode 23, a control grid 24, a screen grid 25, and an output anode 26. The input terminals 6 and 16 are connected with a common ground lead 27 connected separately to each cathode through self-bias resistors 28 and 29 whereby the amplifier devices 8 and 17 may be separately biased for any preferred degree of amplification.

The rectifier circuit 7 is preferably broadly tuned to receive both the signal or carrier wave and the local oscillation voltages, and, in the present example, may be considered to be broadly tuned through the transformer 13 to the 700 kilocycle signal and the 875 kilocycle oscillator signal.

The rectifier circuit includes a diode rectifier device 30 preferably of the hot cathode type having an anode 31 connected with the high potential side 32 of the rectifier circuit and to the high po-

tential end of the secondary 14. The cathode of the rectifier device indicated at 33 is connected to ground 34 and to a resistor or diode output impedance 35 and a tuned circuit 36 with the low potential terminal 37 of the secondary of the input transformer. The resistor 35 is provided with a by-pass capacitor 38 for providing a low impedance to currents at the signal and oscillator frequencies.

The tuned circuit 36 interposed between the secondary 14 and the diode rectifier output impedance 35 comprises a coupling winding or inductor 39 provided with a shunt variable tuning capacitor 36a by which the circuit 36 is sharply tuned to the intermediate or beat frequency.

The inductor 39 is inductively coupled to a second inductor 40 included in a tuned circuit 41 for which it is provided with a shunt variable tuning capacitor 42. The tuned circuit is included in the input circuit of an intermediate frequency amplifier electric discharge device 43, the control grid 44 of which is coupled to the tuned circuit through a coupling capacitor 45. A resistor 46 is arranged to supply a biasing potential to the control grid 44 by a self bias resistor 47 in circuit with a cathode 48 of the amplifier device 43. The return connection to cathode is provided through ground connections 49 with which the tuned circuit grid leak and self bias resistor are provided.

The intermediate frequency amplifier device 43 is the screen grid pentode type having a screen grid 50 and a suppressor grid 51 connected with the cathode. The output anode indicated at 52 is connected with an output intermediate amplifier circuit indicated at 53.

The tuned circuits 36 and 41 are coupled as indicated for the transfer of intermediate signals from the rectifier circuit 7 to the intermediate frequency amplifier circuit 41, the circuit 41 being sharply tuned like the circuit 36 for the transfer of intermediate frequency signals at 175 kilocycles, for example.

The operation is as follows: the input potentiometer for the oscillator amplifier 17 is adjusted to apply to the rectifier 30 an alternating current potential of substantially one volt. The signal control potentiometer 10 is then adjusted to provide substantially the same voltage from the signal source on the rectifier 30 or a signal level approaching that of the local oscillator. For example, in accordance with the curve 54 of Fig. 3, it will be seen from the curve that as the input signal voltage is increased above one volt the developed intermediate frequency voltages fall off rapidly and flatten out with substantially no increase above four volts. This is with a resistance in the rectifier circuit of 50,000 ohms at 35. A curve 55 is also shown for operation of the diode circuit with zero resistance at 35.

The signal and oscillator potential of substantially equal value and at approximately one volt are rectified and the combined signal or beat frequency is applied through the coupled tuned circuits 36 and 41 to the intermediate frequency amplifier 43. Any increase in the signal strength causes no appreciable change in the output of the limiter system above four volts peak from the signal and comparatively slight increase between one volt and four volts as will be seen from the curve 54 of Fig. 3.

Assuming that an oscillator voltage of two and a signal voltage of two, the sum of the voltages is equal to four and the difference equal to zero, when superimposed on each other forming a heterodyne beat. If now a signal of 10 volts be applied with the same oscillator voltage (2 volts) the sum of the voltages will equal twelve and the difference 8 which results in the same envelope amplitude of four volts. Therefore, it will be seen that with the circuits shown, a wide variation in signal amplitude is permissible without changing the output voltage from the limiter circuit.

Referring now to Fig. 2, a radio signal receiver 60 is provided with a normal oscillator 61 and signals from the oscillator and receiver are mixed in an electric discharge mixer device 62 whereby the use of separate amplifier devices is eliminated. In the present example the mixer device comprises a cathode 63, an output anode 64 between which are located two control grids such as an inner control grid 65, the latter being provided with two screen electrodes 67 providing a screen grid structure and a suppressor grid 68 is provided adjacent to the output anode 64 and connected to cathode. Oscillator signals are applied through a tuned circuit 69 and a volume control potentiometer device 70 to the outer control grid 66, the tuned circuit being returned to cathode through a lead 71 and a source of biasing potential 72.

The radio signal is applied to the inner control grid 65 through a tuned circuit 73 and a volume control potentiometer device 74 having a common return to the cathode through the lead 71.

The signals from the oscillator and receiver are mixed in the electronic stream of the mixer device 62. The screen 67 serves to isolate the two input circuits.

The terminals of the tuned input circuits 69 and 73 correspond to the terminals 15, 16, 5 and 6 of Fig. 1. These circuits are relatively sharply tuned to the oscillator and signal frequencies respectively and the adjustment of the volume control means 70 and 74 is such that substantially equal signal and oscillation potentials are applied to the mixer tube control grids.

The output circuit of the mixer tube includes the primary winding 75 of an output transformer 76, the primary winding being broadly tuned by shunt capacitor 77 to both the oscillation and signal frequencies.

The secondary 78 of the transformer 76 is included in the rectifier circuit 79 with the rectifier device 80 having an anode 81 and a cathode 82. The rectifier circuit further includes a rectifier output resistor 83 grounded at one end as indicated at 84 and connected with the cathode and connected at its opposite or high potential end 85 with the low potential end 86 of the secondary winding 78. The output resistor 83 is provided with a shunt bypass capacitor 87 having a low impedance to the signal frequencies to which rectifier circuit is broadly tunable. The combined signal and oscillation potentials or intermediate frequency signal voltage appears across the terminals of the output resistor 83 and is applied between the control grid 88 and the cathode 89 of an intermediate frequency amplifier tube 90 through a coupling capacitor 91 of the screen grid type. The screen grid is indicated at 92 and serves to isolate the rectifier circuit from the output circuit 93 which is coupled to the succeeding stages through an intermediate frequency coupling transformer 94 having a tuned primary winding 95 and a tuned secondary winding 96 to provide a high degree of selectivity immediately succeeding the impedance coupled amplifier and preceding the additional amplifier stages and the second detector (not shown). The

grid 83 is provided with the usual grid leak connection 97 to the cathode and self-bias supply means 98.

The rectifier circuit of the present example operates in a similar manner to that of Fig. 1 to provide an intermediate frequency envelope by the rectification of the signal and oscillator energy applied to the circuit. The intermediate frequency signals applied to the output circuit of the rectifier are limited to substantially the same values by the heterodyne limiter action of the rectifier. An increase in signal strength merely causes the intermediate frequency voltage wave or envelope to be displaced with respect to the axis of rectification. This is true particularly with a detector such as a diode having a relatively sharp cutoff which substantially entirely eliminates the negative portion of each wave or cycle. It is important that the detector have a linear charactertistic, that is, it is necessary to operate over a portion of the detector characteristic which is substantially linear. Confining the operation to a square low characteristic will give diminished limiter action.

From the foregoing description it will be seen that a limiter system in accordance with the invention comprises a mixer circuit for the signal and local oscillator voltages which mixer circuit is relatively broadly tuned and includes a diode detector. The intermediate frequency output circuit from the diode is tuned to the beat frequency derived from the reaction of diode input voltages.

For amplitude modulated signals, the oscillator voltage and normal signal voltage appplied to the rectifier or detector are substantially equal and may be of the order of one volt whereby the detector is operated near its linear characteristic and prevents the intermediate frequency output voltage from exceeding a predetermined low limit in the event that strong signals are received such as may be produced by the reception of static and other noise producing signals. The two tuned coupled intermediate frequency output circuits serve to pass the heterodyne beat or intermediate frequency while suppressing the input signal and oscillation voltages.

Stated in other words, the system described provides a heterodyne limiter which effectively limits the signals to the predetermined amplitude determined by the local oscillator voltage impressed on the limiter.

To receive frequency modulated signals, it will be seen that the signal voltage may be increased to provide a condition of operation with reference to Fig. 3 which provides a signal strength of 5 to 10 times the strength of the local oscillator whereby the limiter operates along the straight portion of the curve above the knee and suppresses amplitude modulation. This change of operation is effected merely by operating the volume control potentiometer of the signal circuit to increase the signal strength above that of the oscillator.

While it has been found with the hot cathode type of diode rectifier, a signal and oscillation voltage of substantially one volt is effective for noise limitation, it should be understood that the invention is not limited thereto. It is desirable, however, that the detector be substantially linear and that the local oscillation voltage be held substantially constant for any adjusted value.

I claim as my invention:

1. In a radio receiving system, the combination with a source of signal voltage and source of oscillator voltage, of a diode rectifier circuit including a diode rectifier device and a diode output resistor, means for mixing the signal and oscillator voltages, means for controlling at least one of said voltages to provide a modulation envelope on the signal voltage wave, means broadly tuned to the oscillator and signal frequencies for applying said mixed voltages to the rectifier circuit to limit the amplitude of the signal voltage by rectification of the modulation envelope, and means for deriving a beat frequency voltage from said rectifier circuit, said means including at least one relatively sharply tuned circuit responsive to the beat frequency.

2. In a radio receiving system, a signal limiter circuit of the heterodyne beat type including a linear detector, a broadly tuned input circuit for said detector, means for applying a modulated signal to said circuit to rectify the modulation envelope, and means for deriving a beat frequency signal from said modulated signal in said detector circuit, said means including an output circuit sharply tuned to said beat frequency.

3. In a radio receiving system, a signal limiter circuit of the heterodyne beat type including a diode rectifier as a limiter, an input circuit for said rectifier broadly tuned to signal and local oscillator frequencies, means for applying an intermediate frequency signal to said circuit to limit the signal amplitude, and means for deriving said intermediate frequency signal from said diode rectifier circuit, said means including an output circuit sharply tuned to said beat frequency.

4. A radio signal limiter comprising substantially linear rectifier means, means providing a signal input circuit for said rectifier broadly responsive to signal and oscillation voltages at frequencies differing by the amount of a predetermined beat frequency, means for applying said signal and oscillation voltages to said circuit, means for adjusting the amplitude of one of said voltages to substantially the same amplitude as the other voltage, an output resistor and a tuned circuit connected in series with said input circuit and said rectifier, and a second tuned circuit coupled to said first named tuned circuit, said circuits being sharply responsive to a signal at said beat frequency.

5. A radio signal limiter comprising diode rectifier means, means providing a signal input circuit for said rectifier broadly responsive to signal and oscillation voltages at frequencies differing by the amount of a predetermined beat frequency, means for applying said signal and oscillation voltages to said circuit whereby the modulation envelope of mixed signals and oscillations is rectified, means for adjusting the amplitude of one of said voltages to provide said modulation envelope and to permit the other of said voltages to be limited in the rectifier circuit, a diode output resistor, an amplifier coupled to said diode output resistor, and a second tuned circuit for said amplifier sharply responsive to signals at said beat frequency.

6. In a radio receiving system, a signal limiter circuit of the heterodyne beat type, comprising substantially linear detector means, a signal voltage source, a local oscillation voltage source, means for impressing signals from said sources on the detector, an output circuit coupled to said detector for passing the heterodyne beat and suppressing the input and oscillation signals, and means for adjusting one of said voltages to

a fixed value below the saturation point of the detector characteristic, and means for adjusting the other of said voltages to provide signal cut-off above the point on said detector characteristic established by said first named voltage.

7. In a radio receiving system, a signal limiter circuit of the heterodyne beat type including a diode rectifier device, means for impressing on said device through said circuit a local oscillation voltage of predetermined amplitude, and means for limiting the signals applied to said rectifier to the predetermined amplitude of the local oscillation voltage, whereby the beat frequency output from said rectifier is substantially constant when one of said voltages exceeds that of the other, by reason of the displacement of the voltage wave with respect to the axis of rectification.

8. In a radio receiving system, the combination of a source of signal voltage, a source of local oscillation voltage, a screen grid amplifier device coupled to each of said sources, volume control means for adjusting the signal and oscillation voltage applied to each of said amplifier devices, a diode rectifier circuit including a diode rectifier device and a diode output resistor, means broadly responsive to the frequency of the oscillation and signal voltages for coupling said diode rectifier circuit to said amplifier devices, tuned output coupling means in said diode circuit between said output resistor and said last named coupling means, an intermediate frequency amplifier device of the screen grid type, and means providing a tuned input circuit for said device inductively coupled to said last named output coupling means, said last named circuit and said output coupling means being sharply responsive to a beat signal resulting from the reaction of the signal and oscillation voltages in said diode rectifier circuit.

9. In a radio signal receiver, the combination of a signal mixer tube having a pair of control grids, a tunable input circuit for one of said control grids coupled to the oscillator, a second tunable input circuit for the other of said control grids coupled to the signal receiver, means for controlling the oscillation and signal voltages applied to said control grids, an output circuit for said device relatively broadly responsive to the oscillation and signal frequencies, a diode rectifier circuit coupled to said output circuit and including a linear rectifier device of the diode type, a diode output resistor in circuit with said rectifier device, an amplifier device coupled to said output resistor, and relatively sharply tuned intermediate frequency output circuit means for said last named amplifier device.

10. The combination with a radio signal receiver and a local oscillator therefor, of a signal mixer tube having a cathode, an output anode, a pair of control grids interposed between said cathode and anode, a screen electrode for one of said control grids, a suppressor grid adjacent to the anode and connected to the cathode, a tunable input circuit for one of said control grids coupled to the oscillator, a second tunable input circuit for the other of said control grids coupled to the signal receiver, means for controlling the oscillation and signal voltages applied to said control grids, an output circuit for said device relatively broadly responsive to the oscillation and signal frequencies, a diode rectifier circuit coupled to said output circuit and including a linear rectifier device of the diode type, a diode output resistor in circuit with said rectifier device, an amplifier device coupled to said output resistor, said device having a screen grid whereby the input and output circuits thereof are electrically isolated, and relatively sharply tuned intermediate frequency output circuit means for said last named amplifier device.

11. In a radio signal receiving system, an intermediate frequency amplifier circuit including in combination, means for receiving a carrier wave at a predetermined frequency, means providing a signal of lower voltage amplitude than the voltage amplitude of the carrier wave to modulate the latter, a circuit for receiving said modulated carrier wave, a substantially linear rectifier in said circuit for rectifying the modulation envelope of said carrier wave, said circuits being relatively broadly tuned to the beat frequency of said carrier wave and modulating signals, and means providing a sharply tuned output circuit coupled to said last named circuit for conveying therefrom the beat frequency signal of said carrier wave and said modulating signals.

12. In a radio receiving system, a signal limiter circuit of the heterodyne beat type including a substantially linear rectifier device, means for impressing through said circuit a local oscillation voltage of such amplitude as to operate the rectifier substantially up to the linear part of its characteristic, means for impressing through said circuit a signal voltage having a normal amplitude substantially equal to or greater than the amplitude of the local oscillator voltage, means for selecting the resultant beat frequency output from said rectifier.

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