

July 20, 1937.

V. D. LANDON

2,087,288

RADIO RECEIVING SYSTEM

Filed June 29, 1935

4 Sheets-Sheet 1

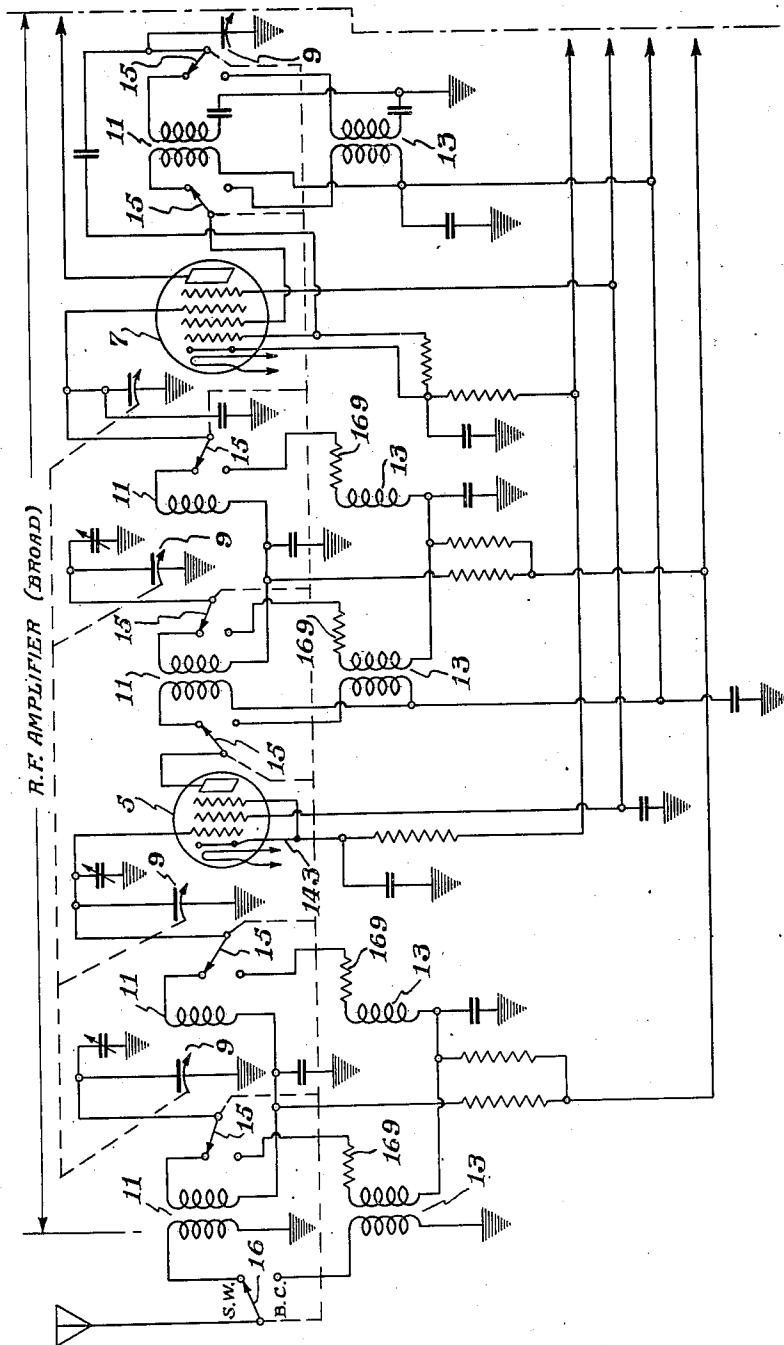


FIG. 1.

Witness:

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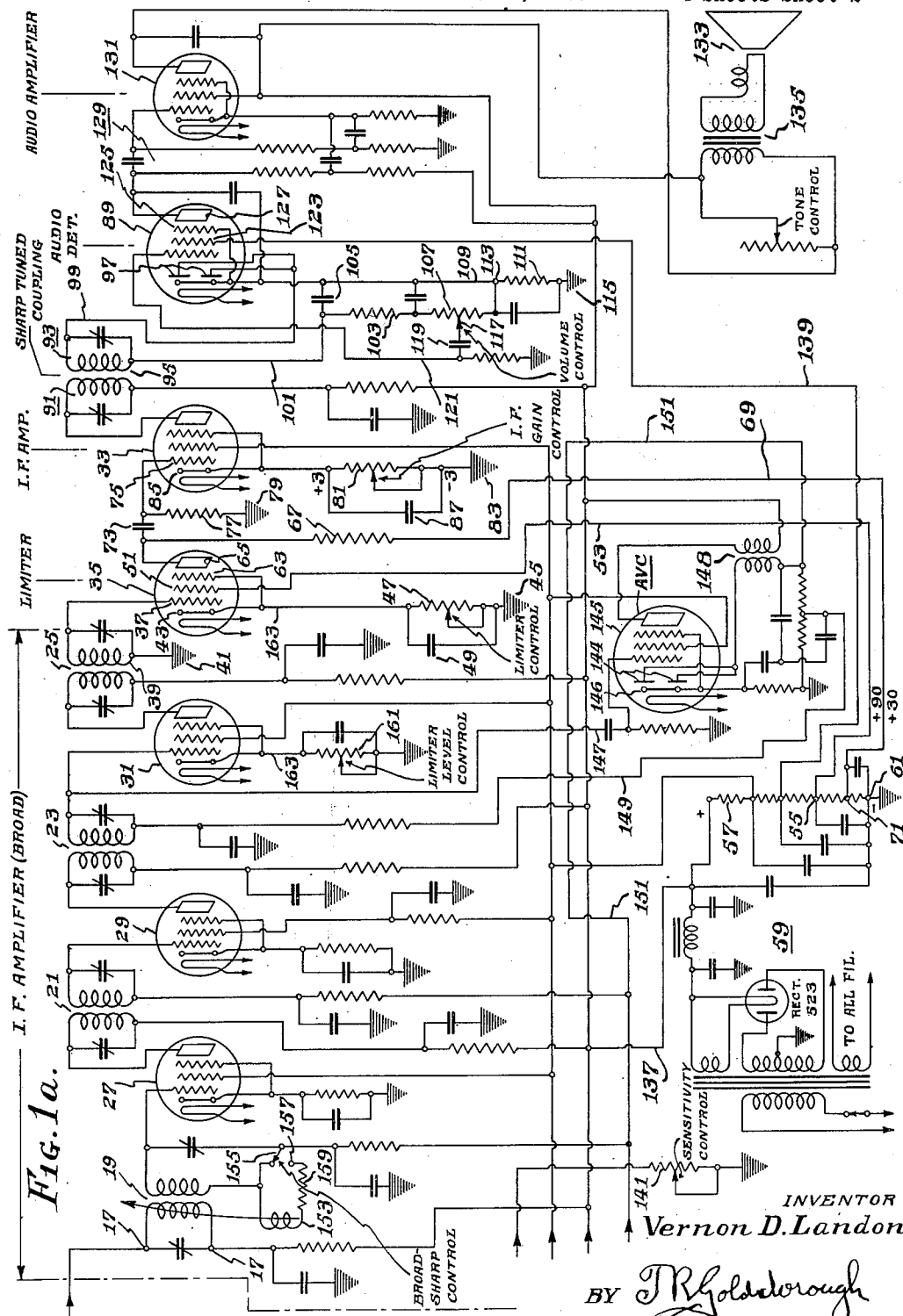
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4 Sheets-Sheet 2



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RADIO RECEIVING SYSTEM

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FIG. 2.

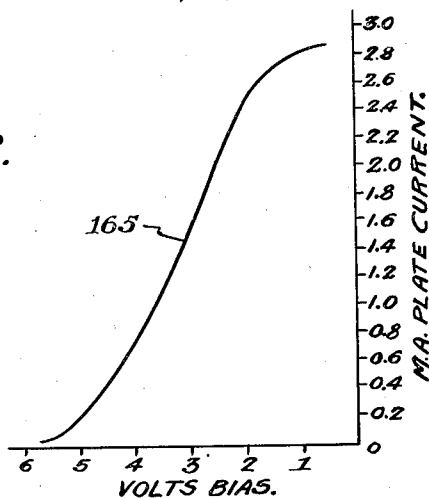


FIG. 3.

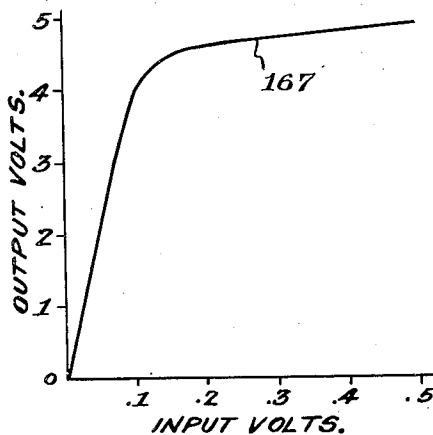
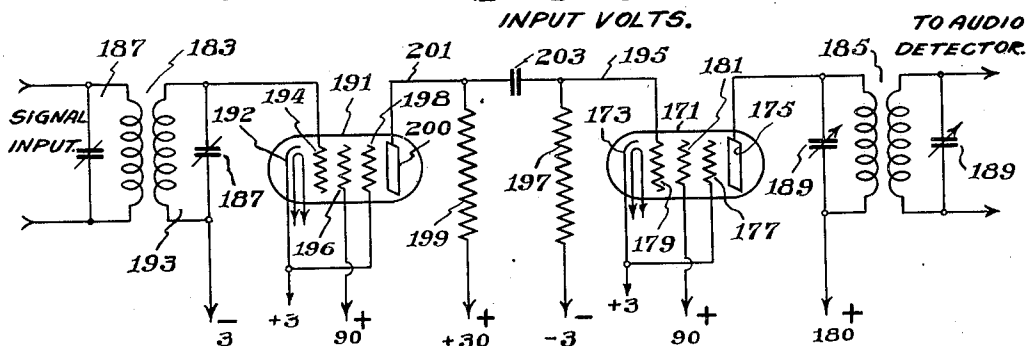


FIG. 5.



Witness

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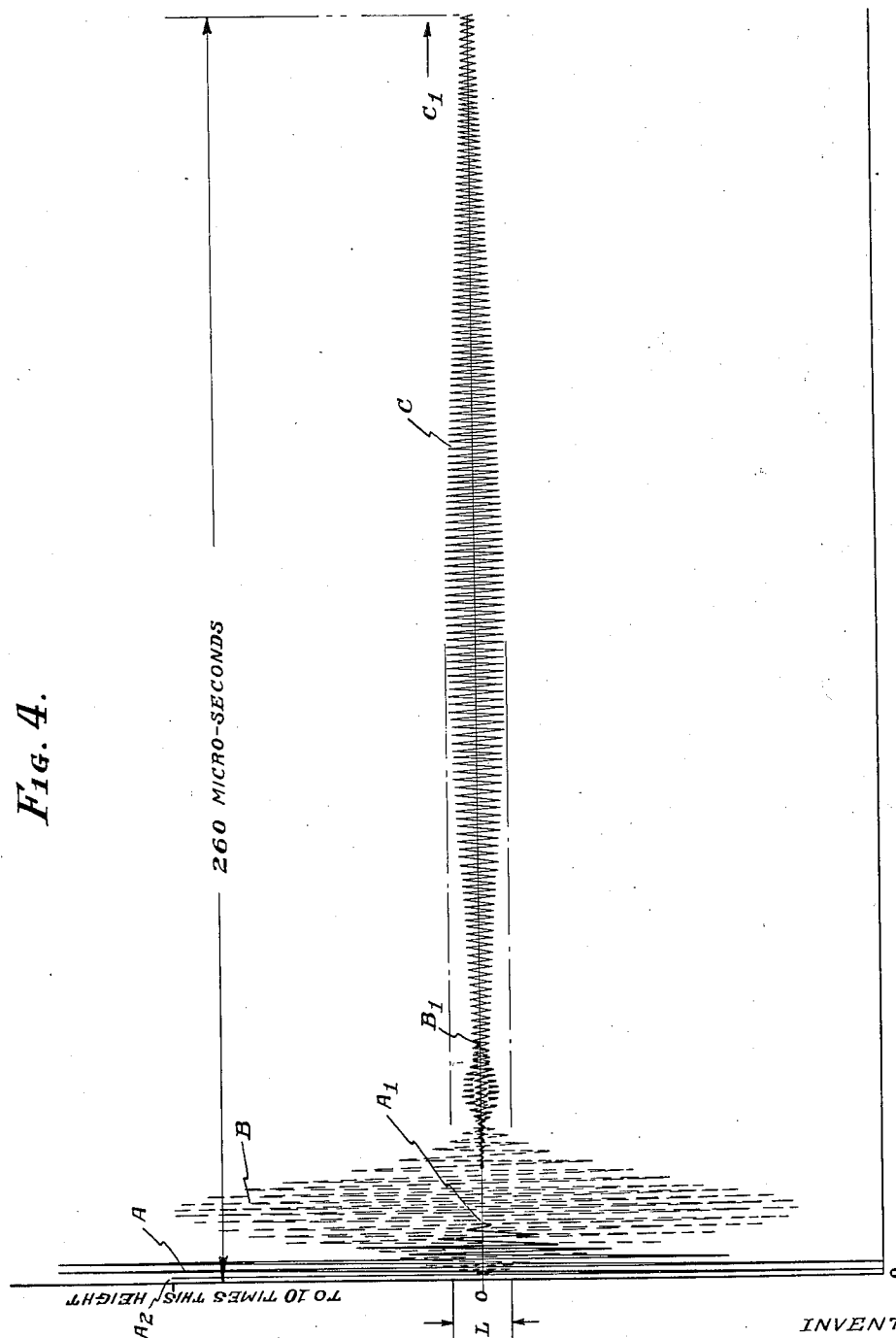
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RADIO RECEIVING SYSTEM

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4 Sheets-Sheet 4

Fig. 4.



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2,087,288

RADIO RECEIVING SYSTEM

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Application June 29, 1935, Serial No. 28,986

12 Claims. (Cl. 250—20)

The present invention relates to radio receiving systems, and has for its primary object to provide an improved radio receiving system wherein noise resulting from the reception of static discharges and other interference waves, may be reduced within the receiving system to relatively low amplitudes sufficiently below the signal level to render the interference therefrom less objectionable.

More particularly, it is an object of the present invention to provide an improved noise reduction system for radio receiving apparatus and the like, including an improved limiter circuit so arranged in the receiving system that the noise reduction is most effective with the least additional apparatus.

It is also a further object of the present invention to provide a radio receiving system, the high frequency signal circuits of which are arranged in predetermined relation to the limiter circuit or circuits and provide predetermined degrees of selectivity with respect to each other.

Heretofore it has been considered necessary to provide a series of highly selective circuits in radio receiving systems in connection with noise limiting devices and circuits. However, in accordance with the invention, it has been found that certain of the receiving circuits may be relatively broadly tuned with increased reduction in the noise level with respect to the signal level, and this is attributed in part to the fact that static and other interference impulses, while of relatively low amplitude in sharply tuned circuits, may persist as oscillations over a relatively long time interval in such circuits. It has been found that in more broadly tuned circuits, the amplitude of the interference waves may reach higher levels but may be attenuated more rapidly. In conjunction with an improved limiter circuit or circuits, a system may be devised which provides much greater improvement in noise reduction than would be expected from mere amplitude limitation. That is, the noise is not merely limited, to the same audio frequency level as the signal, but is reduced to a value far below the signal level.

A limiter system of the type to which the invention relates is shown in the patent to Langmuir #1,468,116 wherein a current limiting device which will eliminate all of the current impulses above a predetermined value is employed to reduce heavy static discharges and, after the large impulses have been removed, suitable tuning apparatus is employed to select the signals of the frequency to be received.

The present invention contemplates an improved limiter device and an improved circuit over that disclosed by Langmuir and specifically, has for its further object, to provide a simplified and improved limiter system of that character for the elimination of static and other undesired impulses tending to create noise in the output of a radio receiving system.

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

Referring to the drawings, Figures 1 and 1A jointly show a schematic circuit diagram of a radio receiving system embodying the invention;

Figs. 2 and 3 show curves illustrating certain operating characteristics of a limiter circuit embodied in the system of Fig. 1;

Fig. 4 shows mathematically derived decay trains for impulses or oscillations applied to two stage amplifiers each having four tuned circuits coupled in groups of two with critical coupling, and illustrating the operation of a receiving system as shown in Fig. 1, and

Fig. 5 is a schematic circuit diagram of a limiter circuit embodying the invention, being a modification adapted for use in the signal amplifying channel of a radio receiving system.

Referring to Fig. 1, the receiving system shown is, by way of example, of the superheterodyne type and is also arranged for multi-range signal reception. A radio frequency amplifier 5 and a combined detector-oscillator or mixer tube 7, are provided with suitable tuning capacitors 9 arranged to be connected with interstage coupling transformers and inductances indicated at 11 and 13 for the short wave and broadcast bands, respectively, through a gang wave-changing switch comprising selector sections indicated at 15 and antenna section 16.

The circuit described represents any suitable high frequency radio receiving circuit comprising a series of tuned circuits in conjunction with suitable amplifier electric discharge devices. As such systems are well known and understood further description is believed to be unnecessary.

In the present example, the receiving circuit provides an intermediate frequency signal which is delivered to the terminals 17 of a multi-stage intermediate frequency amplifier comprising a series of tuned coupling transformers 19, 21, 23 and 25 for high gain electric discharge amplifier tubes 27, 29 and 31 forming the first, second and third intermediate frequency amplifier stages, respectively.

The tuned coupling transformer 25 may be considered as the input transformer for a combined limiter and amplifier unit or stage comprising a fourth intermediate frequency amplifier stage, including an amplifier tube 33, and a limiter circuit comprising a limiter tube 35 of the electric discharge type.

In the present example, the limiter tube 35 is of the screen-grid pentode type having a control grid 37 connected to ground 41 through the tuned secondary 39 of the coupling transformer 25. The tube is further provided with an indirectly heated cathode 43 also connected to ground 45 through a variable resistance device 47 shunted by a suitable high frequency by-pass condenser 49.

The tube 35 is further provided with a screen grid 51 which receives operating potential through a lead 53 from a tap 55 on a potential supply resistor 57 of a power supply unit 59 of the rectified alternating current type. One end 61, of the supply resistor 57, is grounded and the polarity of the direct current supply is indicated at the terminals thereof. A suppressor grid connected to the cathode is indicated at 63, and the output anode of the device 35 is indicated at 65.

The limiter circuit further includes coupling means for the intermediate frequency amplifier tube 33, comprising an anode circuit coupling resistor 67 of relatively low resistance value connected through a lead 69 with a lower positive potential tap 71 than the tap 55 for the screen grid on the supply resistor 57. The anode circuit is thus completed from the anode 65 through the coupling resistor 67 to the tap 71 thence through the potential supply section included between the terminals 71 and 61, and to the cathode through the self biasing control resistor 47. The potential drop in the latter supplies the biasing potential to the control grid 37.

The coupling with the fourth intermediate frequency amplifier tube 33 is completed through a coupling condenser 73 to the control grid 75 of the tube 33 and biasing potential is supplied to said grid through a grid leak resistor 77 grounded as indicated at 79. The biasing potential for the grid 75 is supplied from a self bias source comprising a variable self bias resistor 81 grounded as indicated at 83 and connected with the cathode of the device 33 indicated at 85. The variable self bias resistor is provided with a suitable high frequency by-pass condenser 87 in shunt therewith.

The tuned signal receiving circuits up to the limiter circuit including the device 35 are relatively broadly tuned. As a practical circuit arrangement in the present example, the radio frequency amplifier may be made to respond broadly to signals at any frequency adjustment in a band preferably 50 kilocycles wide, this being within the acceptance band limit for the audio frequency side band requirements.

The intermediate frequency amplifier circuits associated with the transformers 19, 21, 23 and 25 are more broadly tuned, and it has been found that at present, the acceptance band of the intermediate frequency amplifier or band pass characteristic may be increased to 50 kilocycles in width. However, with a further band increase, there is a further improvement in the noise reduction in conjunction with the limiter circuit following it, when the band width is increased up to 500 kilocycles.

Following the limiter circuit which is in the

broad band pass intermediate frequency amplifier, the signal circuits are sharply tuned to narrow band pass limits prior to the second or audio frequency detector. In the present example, the audio frequency or second detector tube indicated at 89 is coupled to the output circuit of the last intermediate frequency amplifier 33 through two tuned coupled circuits 91 and 93 which include the primary and secondary windings respectively, of an interstage coupling transformer 95. The circuits are preferably critically coupled and tuned to the exact intermediate frequency within relatively narrow limits of band acceptance. While one pair of tuned coupled circuits is shown, others may be employed after the manner of the preceding circuits, each of the tuned circuits being sharply tuned to the desired intermediate frequency. The purpose of the sharply tuned circuits following the limiter circuit and preceding the audio frequency detector will hereinafter be described.

In the present system, the audio frequency detector 89 is a tube of the double diode pentode type, the diodes 97 being connected in parallel as a single diode element, to the high potential side or lead 99 of the secondary tuned circuit 93, and the cathode being connected to the opposite side or lead 101 through a suitable filter resistor 103 provided with by-pass capacitors 105 to the cathode, and a diode rectifier output resistor 107, the return circuit to cathode being taken through the cathode return lead 109, thereby completing the diode rectifier circuit. A self bias resistor 111 is included in the cathode return lead 109 between the diode circuit connection 113 and ground connection 115.

Audio frequency signals are conveyed to the pentode amplifier portion of the detector through a movable volume control contact 117 on the diode rectifier output resistor 107, thence through a coupling condenser 119 to the grid input circuit lead 121. The detector is provided with the usual screen and suppressor grids 123 and 125 respectively, and the output anode 127 is coupled through a suitable coupling network 129 with an output amplifier tube 131. The output tube 131 is coupled to a loudspeaker or other suitable output device 133 through an output coupling transformer 135.

The audio frequency detector is preferably of the diode rectifier type, as shown, and may be coupled to any suitable audio frequency amplifier represented by the pentode portion of the detector 89 and the amplifier tube 131. As the audio frequency amplifier does not directly concern the invention, further description thereof is believed to be unnecessary. It will be noted, however, that the anode potentials for the audio frequency amplifier as well as the anode and screen grid potentials and the remainder of the system are taken through suitable leads 137 and 139 from the common power supply means 59.

It will further be noted that the receiving system is provided with a sensitivity control means in the form of a variable cathode lead bias resistor 141 representing any suitable sensitivity control means for the receiving system, and, in the present example, is included in circuit with a cathode lead 143 for the radio frequency amplifier tube 5, thereby to control the gain of that tube by varying the control grid bias thereon.

The sensitivity control means preferably is arranged, as shown, to control the gain or sensitivity of the receiving system in a portion of the

amplifying channel preceding the limiter circuit. Furthermore, automatic volume control means, indicated at 145, may be coupled through a lead 147 with a portion of the amplifying channel, preferably in conjunction with the intermediate frequency amplifier, to provide automatic volume control potentials through control leads indicated at 149 and 151, further controlling the radio frequency amplifier and intermediate frequency amplifier stages in any suitable manner, for automatic volume control purposes. The automatic volume control means is provided with a separate amplifier channel including an amplifier portion of the tube 145 coupled with a rectifier portion including the diodes 144 and a cathode 146, through a coupling transformer 148.

The automatic volume control means controls the amplification or sensitivity of the system in circuits preceding the limiter circuit, and is provided for impressing constant signal level on the limiter circuit.

The selectivity of the receiving system may be adjusted, preferably in one or more of the intermediate frequency amplifier circuits. In the present example, selectivity adjustment means is provided in the input circuit of the first intermediate frequency amplifier 27 and comprises a coil 153 inductively coupled with the primary winding of the transformer 19 and connected in series with the secondary thereof through a selector switch 155. The switch provides connection with a contact point 157 when moved from the normal position shown, to include the coupling coil 153 and a resistor 159 in the tuned secondary circuit, thereby increasing the coupling and decreasing the selectivity of the amplifier input circuit.

When the switch is in the position shown, the selectivity is normal and may be the same as in the succeeding amplifier stages for any preselected side band acceptance, such, for example, as between 50 to 500 kilocycles, as is at present preferred, depending upon the chosen intermediate frequency.

The intermediate frequency amplifier stage preceding the limiter circuit is provided with a limiter level control means comprising a variable self-bias resistor 161 in the cathode circuit 163 of the intermediate frequency amplifier tube 31, the arrangement being such that the control grid bias may be varied thereby, independently of and in addition to the bias potentials supplied by the automatic volume control means 145. By operation of the control device 161, the gain of the intermediate frequency amplifier next preceding the limiter circuit may be varied to control the signal level applied to the limiter. The automatic volume control holds the level constant for all signals. This control varies the level to which signals are held.

Separate control of the limiter action is provided by the variable resistor 47, whereby the grid bias potential on the limiter tube 35 is adjusted. In the signal channel, the fourth intermediate frequency amplifier 33 variable self-bias resistor 81 provides additional gain controlling means following the limiter circuit and preceding the second or audio detector.

Briefly stated, the receiving system includes a signal limiter device, preferably of the type shown, with a tuned signal amplifier having relatively broad band pass characteristic preceding the limiter device, and a tuned signal amplifier following the limiter device, said last named amplifier having a relatively narrow band pass

characteristic, with automatic volume control means for providing signals of substantially constant amplitude to the limiter device.

The limiter circuit depends upon plate voltage saturation for limiting the positive grid part of the cycle, and plate current cut-off for limiting the negative part. In the circuit shown, the anode supply lead 69 for the limiter tube 35 is connected to a lower potential supply point than the screen grid, and with a tube such as that indicated at 35, which may be a tube known commercially as the RCA 6C6, 30 volts at 71 and 90 volts at 55 and with substantially 3 volts negative bias on the grid 37 has been found to be satisfactory for operation of the device in the limiter circuit.

In operation, the limiter circuit should be operated with about 1 volt R. M. S. signal applied to its grid and hence it should, as shown, be preceded by an amplifier if weak signals are to be received. In the present example, it is preceded by both the radio frequency and intermediate frequency amplifiers to insure the required strength of signal. The signal level or R. M. S. voltage applied to the limiter may be adjusted to substantially 1 volt by means of the limiter control means 161.

Referring now to the curves shown in Figs. 2 and 3, the curve 165 plotted between plate current and bias voltage on the limiter tube 35 indicates the direct current operating characteristic of the limiter circuit.

The desirable characteristic curve of the limiter consists of a steep straight operating portion terminated abruptly at each end by a horizontal portion. This is because the signal is to swing the grid over the steep portion without excessive distortion, while larger impulses swinging the grid over the flat portions of the curve, cause only slightly greater fluctuations in output than the signal itself. To obtain this type of curve the voltages given are used, whereby the steep operating portion of the curve is abruptly terminated in the region of -1 volt bias by anode voltage saturation and in the region of 5 volts bias by anode current cut-off. The same type of saturation may be had at lower signal levels by using lower screen and plate voltages and a lower bias voltage. Also raising these voltages gives a limiter which limits at higher signal levels.

The plate resistor should not be made too large or the capacity of the tube will prevent the R. F. currents from following this D. C. curve.

The curve 167, shown in Fig. 3, is plotted between signal input volts on the preceding amplifier stage 31 and the output volts derived from the limiter output circuit as applied to the fourth stage intermediate frequency amplifier 43.

Control 47 is used to adjust the bias of the limiter to the center of the operating portion of the curve 165 of Fig. 2.

The abscissa of curve 167 of Fig. 3 is the voltage applied to a preceding amplifier grid. The voltage applied to the limiter itself is about 2 volts at the knee of the curve or 1 volt half way up the straight portion. Thus if 1 volt is applied there is space for 100% modulation on the straight part of the curve. If the modulation seldom reaches 100%, slightly more carrier may be applied.

The main selectivity of the receiving system is obtained from a circuit or circuits following the limiter. However, sufficient selectivity must be provided in advance of the limiter to reduce

the amplitude of undesired signals to a level somewhat below the amplitude of the desired signal.

The advantage of a wide frequency acceptance band for the tuned circuits preceding the limiter is evident from a study of the theory of decay trains in cascade resonant circuits with impulse excitation and the conclusion reached is that the length of the decay train is inversely proportional to the acceptance band width of the amplifier.

However, the amplitude of the response to an impulse varies directly with band width. Thus the area under the envelope of the impulse train is independent of the band width and this and the above facts will more readily be seen from a consideration of the representation of various decay trains as shown in Fig. 4.

The trains are plotted against time on the horizontal axis, and the total length of time traversed by the entire width of the graph from the left hand margin to the right hand margin is 260 micro-seconds as indicated on the diagram. The heavy oscillatory graph A represents the decay of a wave train in an amplifier having two stages, each having two tuned circuits, such as the circuits connected with the amplifier tubes 27 and 29 in Fig. 1.

The decay train shows rapid attenuation and ends abruptly at A₁, as indicated, with the first impulse A₂ foreshortened in the graph representation, as it extends normally substantially 10 times the height shown and, therefore, could not well be drawn in the same proportion in the space shown. The acceptance band width of the tuned circuits for the diagram A is substantially 500 kilocycles.

The dotted graph B of a decay train starting at the zero point indicated for the graph A and extending to the point B₁, represents an acceptance band width of 50 kilocycles.

When the amplifier circuits are sharply tuned to an acceptance band width of 5 kilocycles, a wave train generated by an impulse may have the form shown by the graph C which starts from the same zero point indicated on the diagram and may extend well beyond the time limit indicated between the right and left hand border lines of the diagram.

It can, therefore, be seen from the oscillation diagrams or graphs of Fig. 4 that the length of the decay train may be inversely proportional to the acceptance band width of the amplifier and that the more broadly tuned circuits serve more rapidly to attenuate the oscillations than the more selective circuits although the amplitude is relatively high in the broader tuned circuits.

It can, therefore, be seen that in accordance with the invention, the opportunity for improvement in noise suppression is much greater than would be expected from mere amplitude limitation. That is, the noise voltage amplitude may not merely be limited to the same audio frequency level as the signal, but may be reduced to a value far below the signal level.

This is accomplished by creating in the preceding amplifier tuned circuits, a condition of operation represented by the curve A, for example, or the curve B to provide a short, high amplitude impulse, and then reducing the amplitude of the impulse by a limiter circuit of the type shown in Fig. 1 in connection with the tube 35 to a limit such as indicated between the lines L in Fig. 4, and finally increasing the duration of the limited short impulse and thereby further reducing the amplitude by passing it through the succeed-

ing sharply tuned transformer 95, following the amplifier 33 which is directly coupled to the limiter circuit. In this manner, the shortened impulse is then extended in much the same manner as the impulse of the curve A is extended to the curve C and its amplitude is in the same proportion reduced to a value far below that of the signal.

It can, therefore, be seen that it is desirable to supply tuned circuits in advance of the limiter circuit of sufficient selectivity to prevent unnecessary interference between signal channels and then to provide sufficient broadly tuned circuits to permit a short decay train before entering the limiter circuit. The amplitude of the decay train is then limited to a predetermined low value such that when passed through the succeeding sharply tuned circuit or circuits the amplitude of the interference wave is but a small percentage of the amplitude of the signal wave and hence the interference is proportionately reduced.

An examination of broadcast frequency assignments shows that at most areas 50 kilocycle operation is maintained between all local and semi-local broadcasting stations. In view of this, it seems logical to utilize a 50 kilocycle acceptance band width in order to obtain an appreciable attenuation at 50 kilocycles from the center of the band. The receiving system shown in Fig. 1 employs an intermediate frequency centering on 425 kilocycles and the acceptance band is 50 kilocycles wide, up to the limiter circuit.

It is desirable that substantially constant intermediate frequency voltage be maintained on the grid of the limiter tube and, for this reason, it is desirable to employ a substantially flat automatic volume control means such as that indicated in the circuit of Fig. 1.

Further referring to the circuit of Fig. 1, in the broadcast band indicated by the letters, B. C. resistors indicated at 169 are employed to maintain a 50 kilocycle band width.

Referring now to Fig. 5, there is shown a static or noise limiter circuit embodying the invention and adapted for insertion in a signal channel of a radio receiving system, preferably immediately preceding the second audio frequency detector.

The circuit is associated with a signal amplifier circuit comprising an electric discharge amplifier tube 171 which may be of the high mu type comprising a cathode 173, an output anode 175, suppressor grid 177 connected with the cathode, a control grid 179 adjacent to the cathode and a screen grid 181 between the control grid and the anode 175.

The amplifier stage is provided with input and output coupling means represented by the input transformer 183 and the output transformer 185. The primary and secondary windings of the transformers are tuned by suitable condensers 187 and 189 to the selected signal frequency to be transmitted by the amplifier stage. The two coupled circuits provided by the input coupling means for the amplifier unit are broadly tuned by the adjustable condensers 187 for a relatively wide acceptance band width including the selected frequency, while the output coupling means is sharply tuned by the condensers 189 which are preferably variable as indicated for this purpose, to a relatively narrow acceptance band including the selected frequency.

By way of example, the amplifier unit shown may represent an intermediate frequency amplifier stage or unit tuned to an intermediate frequency of 425 kilocycles, in which case the tuned

circuits of the input coupling means may be tuned to substantially a 500 kilocycle acceptance band width or 250 kilocycles on either side of the selected frequency of 425 kilocycles.

The output coupling means for the limiter and amplifier unit, on the other hand, may then be tuned for acceptance band width from 5 to 10 kilocycles to provide maximum selectivity immediately following the amplifier stage and preceding the audio detector.

The amplifier tube 171 is not directly connected to the input circuit or input coupling means but, instead, a limiter tube 191 is interposed between the tuned input circuit, which, in this case, is the tuned secondary circuit 193 of the transformer 183, and the input 195, 197 of the amplifier tube 171.

In the present case, the input circuit of the amplifier tube comprises the lead connected with the control grid 179 and the grid leak resistor 197 through which bias potential is supplied to the grid. The operating potentials and values therefor are indicated at the terminal ends of the various leads.

A coupling means having uniform frequency response is provided between the limiter tube 191 and the input circuit 195, 197, and, in the present example, is provided by a coupling resistor 199 as an output impedance coupling element in the output circuit 201 of the limiter. The coupling between the two circuits is provided by a coupling condenser 203 connected between the high signal potential sides of the circuits 201 and 195, as shown.

The limiter tube 191 includes a cathode 192, a control grid 194, a screen grid 196, a suppressor grid 198 and an output anode 200. The device is of the pentode amplifier type and it will be noted that the suppressor grid is connected with the cathode and that the anode is arranged to receive a relatively low positive potential of substantially 30 volts with respect to the positive potential applied to the screen grid, of 90 volts. With this arrangement, the operation of the limiter tube depends upon the plate voltage saturation for limiting the positive grid voltage of the single input cycle and depends upon plate current cut-off for limiting the negative portion of the input cycle.

The limiter circuit, therefore, comprises a broadly tuned input coupling device such as the transformer 183, a sharply tuned output device such as the transformer 185 with tuned impedance coupled pentode devices connected therebetween the first of said pentode devices being operated at a relatively low anode potential with respect to the screen grid potential. The circuit furthermore is adapted to be included in a receiving system preceding the audio frequency detector as indicated.

With this circuit arrangement the noise impulses impressed upon the input circuit of the limiter-amplifier unit or stage are of very high amplitude and small time duration, while the signals are of relatively low amplitude and of long time duration. It is these different characteristics of noise and signal which permits their separation to be accomplished in the combination limiter and amplifier stage shown in Fig. 5. The sharply tuned amplifier output circuit together with the broadly tuned limiter circuit having a coupling means between the limiter and amplifier portion with substantially a flat frequency characteristic permits the character of the noise wave to be made more like that of the signal, that is to

be changed from high amplitude to low amplitude and from small time duration to long time duration. The change in the character of the noise is inversely proportional to the amplifier band width in circuits preceding the limiter amplifier unit.

From the foregoing description, it will be seen that in accordance with the invention, a radio receiving system, preferably of the superheterodyne type, may be provided with signal amplifier circuits preferably substantially broadly tuned, and included means for changing the selectivity and gain both manually and automatically to provide at the output terminals of the broadly tuned receiver portion, a signal of substantially constant amplitude and band width and that the signals are then limited and amplified in a combined limiter and amplifier stage or unit a sharply tuned circuit supplying the limiter device and a broadly tuned circuit being provided for coupling the output amplifier device to a succeeding circuit. Furthermore, the amplifier is preferably provided with individual gain control means while potential control of the signal output of the receiving system is preferably controlled by means located in association with the audio frequency detector or amplifier.

I claim as my invention:

1. In a radio receiving system, means for improving the signal-noise ratio thereof, comprising a signal limiter device, a tuned signal amplifier having a relatively broad band-pass characteristic preceding the limiter device, and a tuned signal amplifier following the limiter device, said last named amplifier having a relatively narrow band-pass characteristic.

2. In a radio receiving system, means for improving the signal-noise ratio thereof, comprising a signal limiter device, a tuned signal amplifier having a relatively broad band-pass characteristic preceding the limiter device, a tuned signal amplifier following the limiter device, said last named amplifier having a relatively narrow band-pass characteristic, and means providing substantially constant signal level at the limiter device.

3. In a radio receiving system, means for improving the signal-noise ratio thereof, comprising a signal limiter device, a tuned signal amplifier having a relatively broad band-pass characteristic preceding the limiter device, and a tuned signal amplifier following the limiter device, said last named amplifier having a relatively narrow band-pass characteristic, said limiter device including a signal amplifier tube having a cathode, anode, and control, screen and suppressor grids, and means for applying to said electrodes potentials for permitting anode potential saturation within the limits of signal fluctuations in one direction and permitting anode current cut-off within the limits of signal fluctuations in the opposite direction, thereby to limit said signal fluctuations.

4. In a radio receiving system, means as defined in claim 3, further characterized by the fact that means are provided for adjusting the operation of said limiter device for limiting the signal amplitude variations to a predetermined level.

5. In a radio receiving system, means for improving the signal-noise ratio thereof, comprising a signal limiter device, a tuned signal amplifier having a relatively broad band-pass characteristic preceding the limiter device, a tuned signal amplifier following the limiter device, said last named amplifier having a relatively narrow band-pass characteristic, means providing sub-

stantially constant signal level at the limiter device, and means for varying the level at the limiter device to which the signals are held by said last named means.

5 6. In a radio receiving system, a signal amplifier unit including a tuned input circuit, an electric discharge amplifier device connected therewith, a second electric discharge amplifier device, means providing an output circuit for said second
10 amplifier device relatively sharply tuned with respect to said input circuit about the same mean frequency, means having substantially uniform frequency response coupling said amplifier devices in cascade relation, and means for operating
15 one of said devices as a limiting means for signals impressed upon said input circuit by anode voltage saturation and anode current cut-off.

7. In a radio receiving system, a signal amplifier unit including a tuned input circuit, a pentode
20 electric discharge amplifier device connected therewith, a second pentode amplifier device, means providing an output circuit for said second amplifier device relatively sharply tuned with respect to said input circuit about the same mean
25 frequency, means having substantially uniform frequency response coupling said amplifier devices in cascade relation, and means for operating one of said devices at a relatively low anode potential with respect to a screen grid potential
30 thereby to provide limiting means for signals impressed upon said input circuit by anode voltage saturation and anode current cut-off.

8. In a radio receiving system, a signal amplifier unit including a tuned input circuit, an
35 electric discharge amplifier device connected therewith, a second electric discharge amplifier device, means providing an output circuit for said second amplifier device relatively sharply tuned with respect to said input circuit about the
40 same mean frequency, means having substantially uniform frequency response coupling said amplifier devices in cascade relation, and means for operating one of said devices as a limiting means for signals impressed upon said input circuit by anode voltage saturation and anode current cut-off, and means for impressing signals
45 of substantially constant amplitude on said input circuit.

9. In a superheterodyne receiver, means providing relatively broadly tuned high frequency and intermediate frequency amplifiers, automatic

volume control means therefor, means providing a second detector, and a combination limiter and intermediate frequency amplifier unit interposed between the intermediate frequency amplifier means and said detector means, said unit comprising a tuned intermediate frequency input, a
5 tuned output coupling transformer having a band pass characteristic relatively narrow with respect to that of the input transformer, a pair of pentode amplifier devices connected between
10 said transformers in cascade amplifier relation, and means for applying to one of said devices an anode potential substantially lower than the screen grid potential whereby it may operate as a limiter device depending upon plate potential
15 saturation for limiting the positive portion of a signal cycle and upon anode current cut-off for limiting the negative portion of said cycle.

10. In a superheterodyne receiver, an output intermediate frequency amplifier unit comprising
20 a pair of resistance coupled pentode electric discharge amplifier devices, and means for applying potentials thereto whereby one of said devices may effectively amplify signals and the other of said devices may effectively limit the amplitude
25 of said signals to a predetermined level.

11. In a superheterodyne receiver, an output intermediate frequency amplifier unit comprising
30 a pair of resistance coupling pentode electric discharge amplifier devices, and means for applying potentials thereto whereby one of said devices may effectively amplify signals and the other of said devices may effectively limit the amplitude of said signals to a predetermined level, said intermediate frequency amplifier unit having a relatively
35 broadly tuned input circuit and a relatively sharply tuned output circuit, and means for controlling an operating potential of at least one electrode of each of said devices thereby to control the gain and the limit of the signal amplitude of signals transmitted through said unit.
40

12. In a radio receiver, a noise limiting system comprising a limiter device, tuned signal circuits having a broad band pass characteristic at least
45 50 kilocycles in width for supplying signals to said limiter device, a signal amplifier coupled to said limiter device and having a tuned output circuit having a relatively narrow band pass characteristic less than 50 kilocycles in width.

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