April 1, 1947. G. J. C. ANDRESEN 2,418,389

AUTOMATIC LIMITER SYSTEM

Filed July 21, 1945 2 Sheets-Sheet 1

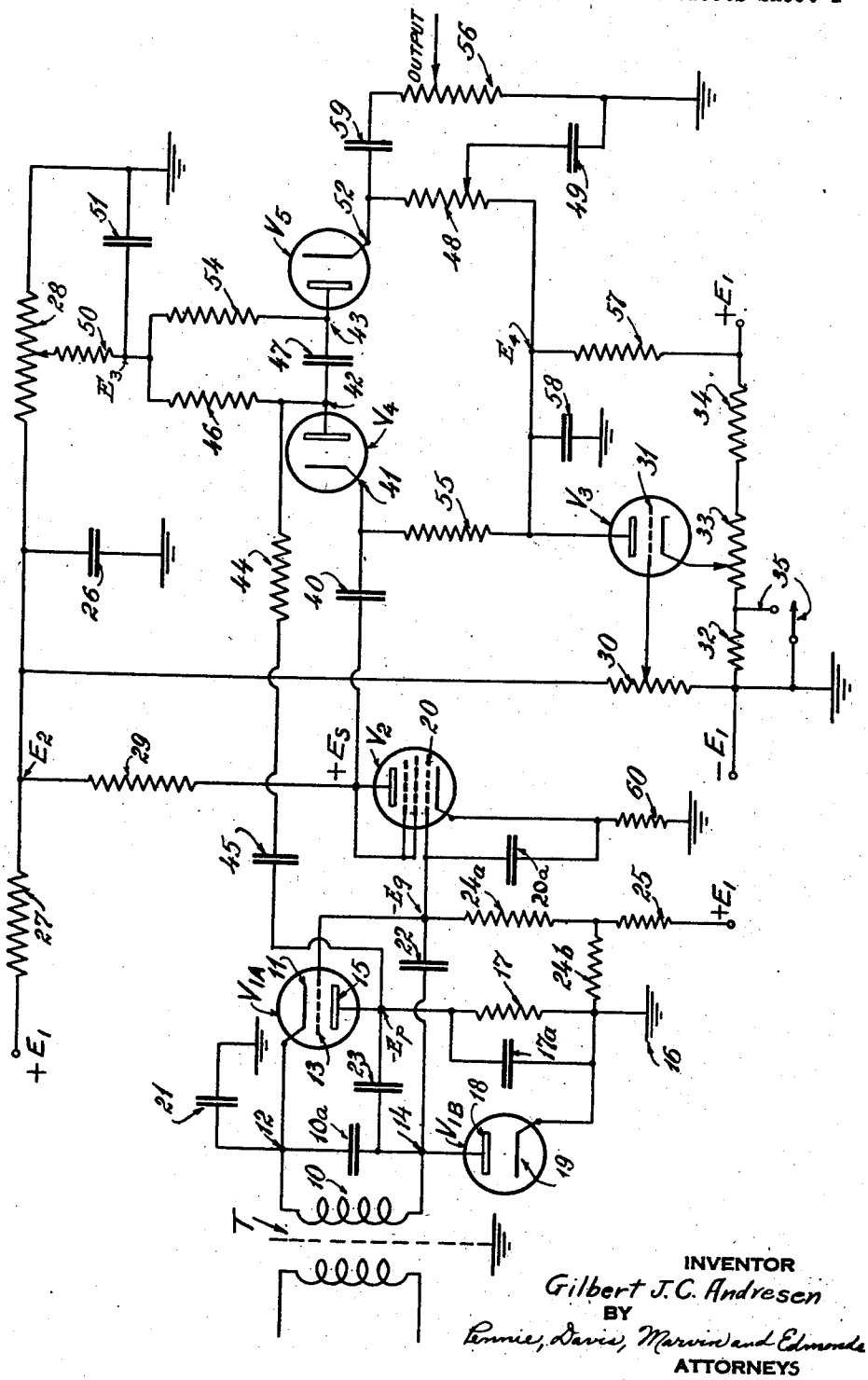


Fig. 1.

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Fig. 2A,

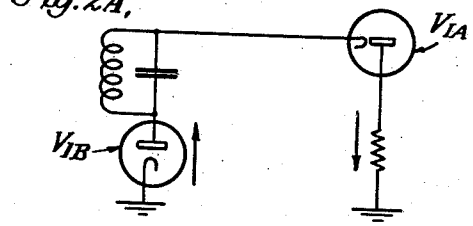


Fig. 2B,

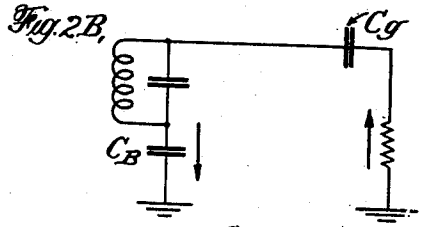


Fig. 2C,

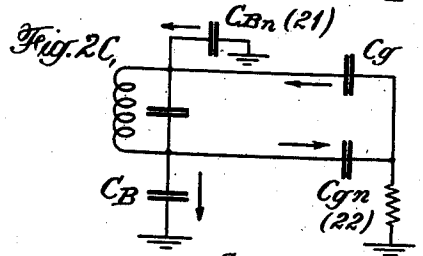


Fig. 2D,

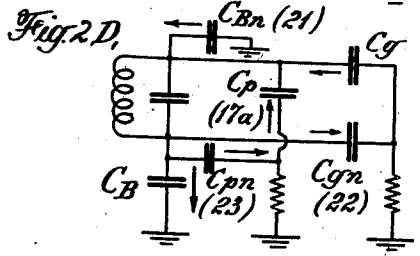
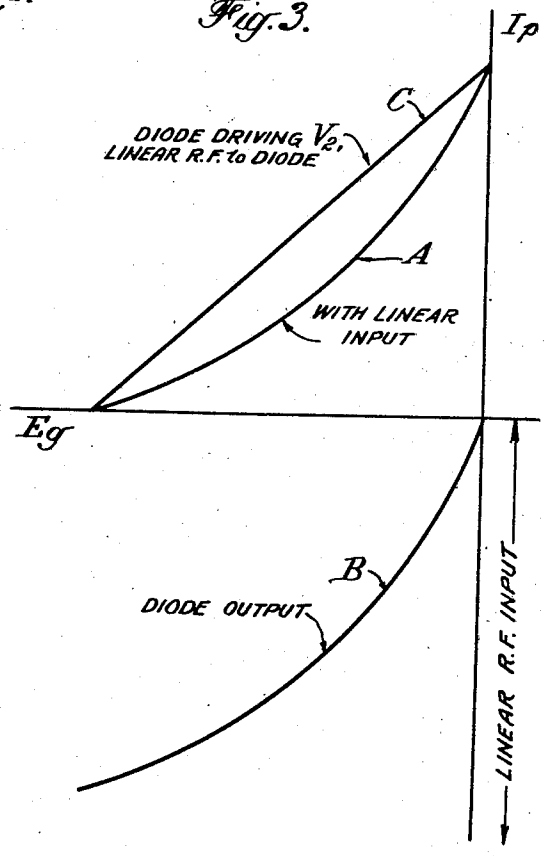


Fig. 3.



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AUTOMATIC LIMITER SYSTEM

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12 Claims. (Cl. 250—20)

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This invention relates to an automatic limiter system for effectively reducing static and noise and the like interference, in the reception of radio signals.

The principal object of the invention is to provide an automatic carrier controlled limiter with which discrimination may be attained, within reasonable limits, between signal and noise in periods of strong static, particularly during the reception of relatively weak signals.

The invention is particularly adapted for use in the reception of voice modulated carrier signals to improve the clarity of speech which otherwise would be distorted, or partially or wholly masked, by the interference.

In accordance with the invention, an improved system is provided comprising in combination several component electron tube circuits and arrangements, some of which are broadly old in the art, others specifically new.

A feature of the invention is a limiter whose cutoff levels are automatically controlled in proportion to the carrier amplitude of the signal, with provision for inverse coupling of strong static pulses in such a manner that their peaks are inverted and are limited at another level.

A preferred embodiment of the invention includes a pair of electron tube rectifiers which are adapted to supply half-wave rectification components of radio-frequency carrier and modulation to an electron-tube voltage regulator, which tube also acts as a reversing repeater for producing an opposite-polarity replica of said components, a supplemental electron tube in the voltage regulator for establishing a gate voltage determining the cutoff leads in a pair of series-limiter electron tubes, and means for coupling the final output to the audio system of a radio receiver.

A complete understanding of the improved system and the mode of operation of the several component electron tubes and circuits of the invention will be had by reference to the following description and to the drawings to be considered in conjunction therewith.

In the drawings:

Fig. 1 is a circuit diagram illustrating the several component electron tubes and the circuit arrangements of a preferred embodiment of the improved system;

Figs. 2A–D show schematically certain current paths in relation to the rectifier; and

Fig. 3 shows certain characteristic curves relating to the regulator amplifier and the signal rectifier.

Referring now to Fig. 1, the invention is illustrated by an embodiment in a radio receiver, of which there are shown only those parts needed to describe the invention. These parts include the detector and the circuits for coupling the detector to the audio-frequency system. For coupling from the intermediate-frequency amplifier to the detector, the transformer T is provided, equipped with shielded primary and secondary to avoid undesired coupling. The electron tube rectifier V_{1A}, a triode, is connected as a diode to the signal input circuit comprising the transformer secondary 10 and the tuning capacitor 10*a*, with its cathode 11 connected to the point 12, and its grid 13, which serves as one diode anode, coupled to the point 14 through capacitance 22. The plate 15 of tube V_{1A}, which serves as another diode anode, is conected to ground 16 through capacitance 17*a* and parallel resistance 17. The electron tube rectifer V_{1B}, a diode used to facilitate neutralization, is connected to the signal input circuit 10, 10*a*, with its anode 18 connected to the point 14 and its cathode 19 connected to ground 16.

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The tube V_{1A} supplies half-waves of radio-frequency carrier and modulation of the signal as a negative potential $-E_g$, to the control element 20 of electron tube V_2, a regulator and radio-frequency limiter and amplifier which serves also as a reversing repeater. A supplemental regulator electron tube V_3, operates in response to tube V_2 to establish a gate voltage determining the cutoff levels in the series limiter electron tubes V_4 and V_5. The output of the system may be applied to the audio system of the radio receiver.

Directing attention specifically to the tube V_{1A} of Fig. 1, the cathode-to-plate and cathode-to-grid load resistors 17 and 24*a* thereof provide leakage paths of high resistance for the signal and static voltages which are rectified in this tube. The rectified half-waves appear across these resistors and are preserved in some degree by making the shunt capacitance 17*a* and 20*a* rather small, perhaps only the inherent capacitance of the circuit elements.

The instantaneous relationship of the various voltages and currents are affected by the anode and grid resistance-capacitance (RC) time constants which, if greater than one-half the carrier period, accumulate substantial negative bias potentials on the diode anodes of tube V_{1A}, of magnitude proportional to the amplitude of the voltage from the input circuit.

To obtain the fastest response in the rectification of the carrier-frequency voltage from the input circuit, the RC time constant of the load of

each diode is made less than the time interval or pulse width of the shortest pulse of noise, as determined by the preceding selective circuits in the receiver. The stray capacitance of the wiring connections and the tubes, and additional capacitance, if present, will not seriously affect the performance, provided the time constant does not exceed the minimum pulse width.

The preferred RC time constant for one-half cycle would be $RC=\frac{1}{2f}$, in which f is the frequency of the voltage applied to the rectifiers.

Referring again to Fig. 1, and in particular to the tube V_{1A} thereof, it is to be understood that the stray capacitance of wiring and the internal capacitance of the tube provide a radio-frequency coupling path across the rectifier, which is the principal path effective during the non-conductive phase.

The diode rectifier tube V_{1B} is connected in series with the ground return of the signal input circuit **10** and is poled the same as the diodes joined by tube V_{1A} to conduct current on the same phase as said diodes. Thus, during the non-conductive phase, both the tubes V_{1A} and V_{1B} and their wiring connections still provide capacitive coupling to the output circuits of the diode rectifiers, namely, resistors **17** and **24***a* and the subsequent circuits coupled thereto.

The small capacitors **21**, **22**, **23**, are provided to neutralize or balance out this capacitive coupling to the output circuit. During the non-conductive phase, the capacitor **21** and the capacitance of tube V_{1B} are connected in series (through ground leads) across the input circuit, and their junction is connected to ground. This forms a bridge circuit such that alternating voltages of opposite polarity appear at points **12** and **14** on opposite sides of the input circuit **10**. By virtue of this bridge circuit, capacitor **22** neutralizes the cathode-to-grid capacitance of tube V_{1A}, and **23** the cathode-to-plate capacitance of tube V_{1A}.

Figs. 2A–D are simplified diagrams of those parts of Fig. 1 that are involved in the neutralization, and are shown to facilitate the explanation of this function.

Fig. 2A shows schematically the current path, and by arrows, the direction of electron flow, during the conductive phase of the rectifier, referring to either of the diodes in tube V_{1A}. Figs. 2B–D show the capacitive current paths effective during the non-conductive phase of the rectifier and make clear the means of effecting complete or approximate balance of the capacitive coupling as above described.

In Fig. 2B the flow of capacitive current during the non-conductive phase is shown, the cathode-grid diode of tube V_{1A} and the tube V_{1B} acting as capacitive coupling means C_g and C_B, respectively. The arrows in this and subsequent figures show the direction of capacitive currents in various parts of the circuit at the same instant, chosen arbitrarily for the purpose of explanation. Fig. 2C illustrates the balancing of capacitance C_g by capacitor **22** (C_{gn}), C_g denoting the cathode-grid capacitance in tube V_{1A} and wiring. Fig. 2D shows in addition the balancing of capacitance C_p by capacitor **23** (C_{pn}), C_p denoting the cathode-plate capacitance in tube V_{1A} and wiring. The balancing of the capacitive coupling paths results in the required approximate neutralization of the tendency for radio-frequency current to be coupled to the diode loads during the non-conductive phase.

Referring again to Fig. 1, and in particular

to the rectifier load **24***a*, there is sometimes developed at the point $-E_g$ an undesired amount of negative potential caused by electron flow. To counteract that undesired condition, a divided load resistor **24***a*, **24***b* is provided and a small opposing current is supplied in resistor **24***a* through the resistor **25** from the power supply voltage source $+E_1$.

If it is desired to provide the usual grid bias on the tube V_2, a cathode resistor **60** may be employed as shown in Fig. 1. If a resistor **60** of proper value is used, resistors **24***b* and **25** may not be required. The negative feedback action of the voltage drop across resistor **60** serves to reduce distortion and to permit a higher input voltage to be applied to the control element **20** before overloading occurs.

As pointed out above, the negative half-waves of radio-frequency voltage of the rectifier output are supplied to the control electrode **20** of the voltage regulator electron tube V_2. Thereupon the output current of this tube will decrease in proportion to the voltage from the rectifier.

It is not necessary to control tube V_2 with the resultant sum of the half-waves. It may be preferable to actuate the control electrode **20** thereof by the voltage of each increment. In that case, the internal resistance of V_2 should be restored quickly to its no-signal value between the half-wave conducting phases of the rectifier to assure the fast operation which is required to follow static pulses.

Assuming the presence of a strong pulse of static, the internal resistance of tube V_2 will become infinitely high during the first negative half-wave of the series of half-waves. If the internal resistance is infinite, the capacitor **26** will charge to a higher potential through resistor **27** from voltage source $+E_1$. The voltage of $+E_1$ is assigned the least value which permits the regulator to function over a wide range of signal strengths; its small voltage prevents the static pulse amplitude from exceeding a limited amplitude preferably not much greater than that of the signal.

During a static pulse the capacitor **26** is momentarily charged at a more rapid rate, but the first rectified half-wave during the conductive phase is followed by the non-conductive phase of the rectifier and the internal resistance of V_2 is restored to a low value. Whereupon the energy stored in capacitor **26** is discharged at a rate several times the charging rate. That effects a rapid decay of the static charge on capacitor **26** during the non-conductive phase of the rectifier. The signal half-wave increments which immediately follow the static are therefore more effective in restoring the internal resistance of the tube V_2 to its normal value determined by the signal carrier intensity.

The regulator tube V_2 may be considered as a resistance in a voltage-divider network including also resistors **27**, **28**, **29**, **30**. The voltage source E_1 being constant, any change in voltage in the network is caused by variation of the internal resistance of the tube V_2 determined by the instantaneous voltage on the control electrode **20**.

As explained hereinbefore, in the absence of signals the preferred voltage on the control electrode **20** is zero. During the negative half-cycle of the signal, the control voltage is negative and of a value directly proportional to the amplitude of the radio-frequency voltage applied to the rectifiers. During the positive half-cycle of the sig-

nal the control voltage should be zero or preferably as near thereto as it is possible to attain.

In the absence of capacitor 26, the voltage at any point of the voltage-divider network, including the tube V_2, alternately would change from a low initial value to some higher value in proportion to the instantaneous voltage of the negative half-cycle. Then, during the positive phase of the signal when the control grid 20 is substantially at zero voltage, it would return to the low initial value. The maximum voltage which any point may attain is limited by the voltage $+E_1$ of the source.

If it is desired to obtain regulated voltage free of the signal half-cycle ripple, a capacitive filter may be employed at any point along the voltage-divider network. The capacitor 26 associated with the voltage-divider network is connected at the common terminal of the resistors 27, 28, 29, 30. Then the voltage E_2 at this junction will not fluctuate with the instantaneous value of the signal and the static modulation, but will have an average value resulting from the operation just explained.

The voltage regulation at E_2 is such that the effects of static pulses are largely overcome, insofar as their peaks are limited by cutoff in tube V_2, and the energy introduced in capacitor 26 by static pulses is reduced to a negligible amount.

The rectified voltage output $+E_s$ from the regulator tube V_2 is limited by the voltage E_2, since that part of E_1 is held uniform during pulse modulation by capacitor 26.

The output of the half-cycle radio-frequency voltage $+E_s$ includes the rectified modulation of the carrier, and when the half-wave increments thereof are impressed upon an audio system the original modulations are reproduced.

The regulator tube V_2 is preferably of the variable-m_μ type and is, therefore, adapted to operate with a high voltage input. However, a conventional triode tube, screen-grid tube, pentode or beam tube can be used. The pentode or beam tube, for example, would provide satisfactory limiter or cut-off characteristics if the input and element voltages are held within limited values.

Ordinarily the output current of the tube V_2 connected as a triode, and having a negative potential impressed upon its control electrode 20, would have a characteristic curve like A of Fig. 3. The rectified output voltage of the rectifier is plotted along the abscissas to represent the negative voltage $-E_g$ applied to the control electrode 20 of tube V_2. The output current I_p of tube V_2 is plotted along the ordinates. If the rectifier characteristic is adjusted to be substantially as in curve B of Fig. 6, the resultant negative voltage impressed upon control element 20 of tube V_2 will produce an output current characteristic substantially as in C, a substantially linear relation with respect to the radio-frequency input voltage $-E_g$. In other words, the curvature of rectification in tube V_{1A} will compensate for the curvature of amplification in tube V_2 to effect a linear response to modulation of the input signal.

Electron tube V_3, Fig. 1, operates as a supplementary carrier-controlled voltage regulator and develops a differential voltage between the points E_3 and E_4 as a limit or gate voltage for the series-limiter electron tubes V_4 and V_5.

The grid voltage applied to grid 31 of tube V_3 is directly proportional to the voltage E_2 and to the signal carrier voltage. The voltage applied to the grid 31 of the tube V_3 is adjusted

along the voltage-divider resistor 30 until the plate current of the tube causes the voltage at point E_4 to decrease at such a rate with respect to the voltage at point E_3, with increase of carrier amplitude, that the differential limiter voltage (E_4-E_3) is in proper adjustment for the desired amplitude limiting as the signal carrier intensity varies. The grid cathode voltage also may be adjusted further by resistors 32, 33, 34, on which the cathode is tapped.

The cathode potential of tube V_3 is preferably to be adjusted by resistor 33 when the switch 35 shunts resistor 32. The cathode potential should be adjusted during absence of signal to make the input voltage to the grid 31 such that the voltage at point E_4 is just sufficient to cut off the series limiter tubes V_4 and V_5. The purpose of providing switch 35 is that with resistor 32 in circuit, the carrier signal strength must exceed a certain minimum before the control voltage applied to element 31 of tube V_3 will bring the limit voltage at point E_4 to a value which will permit the signal to pass through the limiters V_4, V_5.

When no static or noise is present the voltages at points 41 and 42 are permitted to vary up to the value of the voltage E_3 before the point 42 becomes negative with respect to point 41 and the limiter rectifier V_4 opens up. Thereafter for all greater values of rectified and amplified voltage E_s the limiter is non-conductive. With proper adjustment as described above, the signal carrier actuates the regulator in such a manner that the limiter V_4 stays closed for the normal range of modulation, but opens up on peaks of greater amplitude such as strong pulses of static.

While the clipping of static pulses is known to be a great aid in reception, this invention gains a major advantage by a further action, namely, inversion of the strong pulses which otherwise would cause the loudest residual clicks. The inverson requires two coupling paths for rectified modulation from the detector to the limiter. The first is a direct coupling path, which predominates in the amplitude range of normal modulation but which is cut off at greater amplitudes. The second is an inverse coupling path which predominates at greater amplitudes and causes inversion of the peaks of strong pulses.

In Fig. 1, the direct path is through the repeater V_2, which conveys the desired modulation. The inverse path is through the capacitor 45 and resistor 44, which detour around the limiter V_4 so this path is not subject to its clipping action.

Now considering the performance toward a signal accompanied by strong pulses of static, the pulse peaks coupled to point 42 for example, by resistor 44 and capacitor 45 from $-E_p$ predominate at instants when the tube V_4 is cut off. The static pulse voltage is weakly coupled to point 42 so that the anode voltage of V_4 becomes less positive, cutting off further passage of the static pulse through V_4. The value of resistor 44 should be such that strong static will not modulate the voltage at point 42 beyond the zero axis value of the signal while unmodulated. The capacitor 45 should be of sufficient value to prevent any substantial phase shift in the passage of the pulse current from $-E_p$ to point 42.

As insurance that the inverted pulse peak will not recede past the zero axis of the modulation, there is added a second electron tube limiter V_5 coupled by capacitor 47 to V_4 and having a

separate gate voltage. The limiter V_5 is adapted to operate and limit on the inverted peak of a strong static pulse.

The output of V_5 has a time constant determined by resistor 48 and capacitor 49, of the same order of magnitude as the period of the highest modulation frequency to be reproduced. The anode gate voltage to V_4 has a time constant determined by the resistor 50 and capacitor 51, which is of the same order of magnitude as the period of the lowest frequency of modulation to be reproduced. The advantages gained by the use of limiter V_5 as just described, are that the coupling of the inverse peak of the static pulse can be increased to obtain a more precise limiting thereof, and that compensation may be effected during the static pulse for the biasing of points 41 and 42, respectively.

The inverse peak of a strong static pulse at point 42 is coupled to point 43 making tube V_5 non-conductive beyond a certain point, for the reason that the time constant 48, 49, effective at point 52 will not permit the voltage on the cathode of V_5 to follow the sudden inverse peak at point 43. Before equilibrium can be established between point 52 and point 43, tube V_4 has cut off in the manner explained hereinbefore. This mode of operation effects a very sharp cut-off of the static pulse because the inverse coupling may be increased to permit the effective use of rapid charging of the small interelectrode capacitance, wiring connection capacitance, etc., of the limiter tubes V_4 and V_5.

During the static pulse interval the limiter between points 43 and 52 prevents the inverted peaks from passing the zero axis value of the signal modulation. This is a desirable mode of operation because the inverted peak amplitude is within the range of normal modulation.

When the static pulse voltage has decreased from its peak to a value where the regulator V_2 output voltage E_3 combined with the accumulated charge on capacitors 40 and 47 makes point 41 negative with respect to point 42, the limiter V_4 becomes conductive and V_5 is already conductive so the normal response to modulation is resumed.

In the absence of a static pulse the limiters V_4 and V_5 remain conductive to signal amplitudes of the full range of the differential voltage of E_3 and E_4.

The operation of the limiter as a whole will be summarized briefly with reference to the essential functions of some parts of the circuit as described above. The principal parts are the signal detector including tubes V_{1A} and V_{1B}, the reversing amplifier including tube V_2, the inverse coupling path including resistor 44, the limiter including tubes V_4 and V_5, and the gate-voltage regulator including tubes V_2 and V_3.

The signal detector utilizes the rectifier tube V_{1A} to deliver rectified signal voltages of negative polarity from electrodes 13 and 15, both acting as anodes. The other rectifier tube V_{1B} is needed only to preserve the potential at point 14 during the non-conductive phase of V_{1A} and thus permit the neutralizing capacity 22 to be effective.

The reversing amplifier utilizes the tube V_2 to reverse and amplify the rectified signal received from electrode 13 of the detector. The amplified signal is coupled from the anode of tube V_2 through the capacitor 40 to the limiter. In the usual manner, the signal is reversed in this amplifier, so the amplified signal coupled through the capacitor 40 may be regarded as positive, meaning that outward modulation of the signal causes a change of voltage in the positive direction. Since this amplifier provides the principal coupling from the detector to the limiters, it is termed the direct coupling circuit in contradistinction to the inverse coupling circuit now to be identified.

The inverse coupling circuit utilizes resistor 44 to couple to the limiter the rectified signal received from electrode 15 of the detector. This signal is negative in polarity, and is therefore inverse relative to the positive signal output from the amplifier. The purpose of this coupling will be further summarized below.

The limiter includes two rectifier tubes connected in series opposition for limiting the signal in both directions corresponding to outward and inward modulation. The first tube V_4 is poled to cut off beyond a certain level of outward modulation. The second tube V_5 is poled oppositely to cut off beyond a certain level of inward modulation.

When a peak of the signal envelope, for example a static pulse, has a peak voltage exceeding the cutoff level for outward modulation, as defined above, it is applied with positive polarity to point 41 and the cathode of limiter tube V_4, and causes this tube to become non-conductive. Therefore the peak of this pulse is not coupled in this tube through the limiter. However, the inverse coupling path through resistor 44 is still operative on the peak of such a pulse and couples the peak with reverse polarity to the point 42 in the limiter, detouring around the tube V_4 which is cut off. Therefore the peak of the pulse appears inverted in the output of the limiter so the peak is actually at a level lower than the above identified cutoff level for outward modulation. This is one of the principal advantages of the present invention, because thereby the effective peak amplitude of a strong pulse is actually reduced to a level less than the level at which the highest signal peaks of modulation are permitted to pass without distortion.

It is desirable that the inverse static pulse should not indent the signal too far. The second limiter tube V_5 achieves this purpose by limiting any excessive peak values of inverse pulses. Furthermore, by relating the time constant of resistor 48 and capacitor 49, in the limiter output circuit, to the highest modulation frequency, the limiting level for pulses of short duration of either signal or static can be reduced without detriment to the desired modulation components of lower frequencies and maximum amplitude. The clipping of short pulses of modulation at a level lower than low-frequency components of modulation is permissible because the desired modulation seldom includes short pulses of strong modulation.

The gate-voltage regulator circuit utilizes tubes V_2 and V_3 to establish in the limiter certain cutoff levels automatically controlled in response to the carrier amplitude of the signal. These tubes are connected in the manner of a direct-current amplifier so that the rectified carrier voltage from electrode 13 of the detector causes a proportional change of voltage E_4 across the capacitor 58. The latter voltage is applied to the limiter tubes V_4 and V_5, in conjunction with the voltage E_3 across capacitor 51. This voltage E_3 is obtained primarily from the constant source E_1 and increases somewhat, under the influence of tube V_2, with increasing carrier amplitude. The difference of these two voltages determines the cut-

off level of both tubes in the limiter. The ratio of proportionality is so adjusted by the voltage divider 30 that the limiting levels increase with carrier amplitude just at the rate required by the corresponding modulation amplitude in the limiter. This operation is obtained in conjunction with the adjustments of voltage dividers 28 and 33 to set the limiting levels at the zero axis when there is no carrier voltage. The result of the gate-voltage regulator is to insure that the beneficial action of the limiter is secured automatically for any signal strength within the useful range of the receiver.

As mentioned above, the rectified half-waves of the signal are present in the output of the detector V_{1A} and also in the output of the tube V_2. By the usual properties of rectification, the voltage half-waves carry an alternating-voltage component of modulation frequencies and a direct-voltage component of carrier amplitude. For purposes of regulation, the latter is obtained across capacitor 26 and finally corresponding direct potentials across capacitors 51 and 58, all of these capacitors being so large that they cannot be charged and discharged at pulse modulation frequencies.

In the foregoing description, it is presumed that a strong pulse of static superimposed on a modulated carrier has all the appearances of a pulse of modulation, that is, an excessive peak in the modulation envelope. A static pulse is distinguished only if its peak amplitude exceeds the modulation peaks of the signal. In that case, the present invention minimizes its disturbing effect by reducing its peak value as it remains in the output of the limiter. By adjusting automatically the gate voltage of the limiter in proportion to the carrier amplitude, the limiter is enabled to identify static peaks just above the signal peaks, regardless of what that level happens to be for a signal of any given strength.

The preferred embodiment of the invention has been successfully employed as an automatic carrier-radio-frequency controlled limiter in conjunction with commercial receivers, RCA type CRV-46151, among others, for the reception of voice modulated carrier signals. The following tabulation of circuit constant values and types of electron tubes identifies those employed in the system in conjunction with the RCA receiver type CRV-46151 for the successful reception of voice modulated signals through both atmospheric static and locally produced noises. It is as follows:

V_{1A}—Single section of RCA 6SL7.
V_{1B}—Diode rectifier—may be contained in the V_2 envelope such as an RCA 6SF7.
V_2—RCA 6SK7 or 6SF7.
V_3—Single section of an RCA 6SL7.
V_4, V_5—RCA 6H6.
17—36 K ohms.
24*a*, *b*—Section *a*, 100 K ohms; section *b*, 500 to 1000 ohms.
32—0 to 10 K ohms.
29, 33—100 K ohms.
34—150 K ohms.
25, 27—250 K ohms.
50, 46, 54—500 K ohms.
55, 48, 56—1 megohm.
44—.5 to 5 megohms.
57—1–10 megohms (high values preferred).
21 (C_{Bn}), 23 (C_{pn}), 22 (C_{sn})—Neutralizing capacitors 3–10 $\mu\mu f$.
17*a* (C_p), C_s—Load capacitances usually inherent strays—approximately 10 $\mu\mu f$.
51, 49—.001 μf.
45—.001 to .01 μf.
26, 58—.001 to .05 μf.
47—.01 μf.
40, 59—.05 μf.
60—0–5,000 ohms.

The improved system and its components comprising the preferred embodiment of the invention may be modified without departing from the gist and scope of the invention as those skilled in the art will recognize. Therefore, only such limitations as may be imposed by the pertinent prior art should be considered in relation to the appended claims.

I claim:

1. A signal coupling and amplitude limiting system comprising, an input circuit including a rectifier providing rectified voltage in response to a modulated carrier signal, an output circuit, direct and inverse circuits coupling said input and output circuits with opposite polarities, a rectifier connected in said direct circuit, and voltage regulating means including integrating means responsive to the carrier amplitude of said modulated-carrier signal for applying to said rectifier in said direct circuit a gate voltage to limit the peaks of amplitude in said direct circuit at a cut-off level proportional to the carrier amplitude, said direct and inverse circuits each providing substantial coupling and being so proportioned that the direct circuit provides the greater coupling for amplitudes below said cut-off level, whereby the peak of any pulse exceeding said cut-off level is inverted.

2. A system in accordance with claim 1 including a rectifier connected in the inverse coupling circuit and means applying a gate voltage to said rectifier causing said rectifier to limit the peaks of amplitude in the inverse circuit at a cut-off level determined by the gate voltage on said rectifier, said direct and inverse circuits being so proportioned that the inverse cut-off level is beyond the direct cut-off level and the direct circuit provides the greater coupling for amplitudes below its cut-off level, whereby the peak of any pulse exceeding the direct cut-off level is inverted to the extent of the limit imposed by the inverse cut-off level.

3. A system in accordance with claim 2 in which the means for applying gate voltage to the rectifier in the inverse circuit is a voltage regulating means including integrating means responsive to the carrier amplitude of said modulated carrier signal whereby the peaks of amplitude in the inverse circuit are cut off at a level proportional to the carrier amplitude.

4. A system in accordance with claim 3 in which each of the rectifiers is poled to limit outward modulation in its respective circuit.

5. A system in accordance with claim 4 in which the rectifier in the inverse circuit is connected also in the direct circuit, whereby the same rectifier serves to limit outward modulation in the inverse circuit and inward modulation in the direct circuit.

6. A system in accordance with claim 5 in which the rectifier which provides rectified voltage in response to the modulated carrier signal provides rectified voltage of one polarity and in which one of the coupling circuits includes a reversing repeater providing voltage of opposite polarity.

7. A system in accordance with claim 1 in

which the rectifier in the direct circuit is poled to limit outward modulation.

8. A system in accordance with claim 7 in which the rectifier which provides rectified voltage in response to the modulated carrier signal provides rectified voltage of one polarity and in which one of the coupling circuits includes a reversing repeater providing voltage of opposite polarity.

9. A system in accordance with claim 1 in which the rectifier which provides rectified voltage in response to the modulated carrier signal provides a rectified voltage of one polarity and in which one of said coupling circuits includes a reversing repeater providing an opposite polarity of voltage.

10. A signal coupling and amplitude limiting system comprising, an input circuit including a rectifier providing rectified voltage in response to a modulated carrier signal, an output circuit, direct and inverse circuits coupling said input and output circuits with opposite polarities, a rectifier connected in each of said coupling circuits and poled to limit outward modulation in its respective circuit, voltage regulating means including integrating means responsive to the carrier amplitude of said modulated-carrier signal for applying to the rectifier in one of said coupling circuits a gate voltage to limit the peaks of amplitude in the circuit of said rectifier at a cut-off level proportional to the carrier amplitude, means for applying a gate voltage to the rectifier in the other coupling circuit causing said rectifier to limit the peaks of amplitude in the said circuit at a cut-off level determined by the gate voltage on said rectifier, said direct and inverse circuits each providing substantial coupling and being so proportioned that the inverse cut-off level is beyond the direct cut-off level and the direct circuit provides the greater coupling for amplitudes below its cut-off level, whereby the peak of any pulse exceeding the direct cut-off level is inverted to the extent of the limit imposed by the inverse cut-off level.

11. A system in accordance with claim 10 in which the rectifier which provides rectified voltage in response to the modulated carrier signal provides rectified voltage of one polarity and in which one of the coupling circuits includes a reversing repeater providing voltage of opposite polarity.

12. A signal coupling and amplitude limiting system comprising, an input circuit including a rectifier providing rectified voltage of one polarity in response to a modulated carrier signal, an output circuit, direct and inverse circuits coupling said input and output circuits with opposite polarities, a reversing repeater in one of said coupling circuits providing the voltage of opposite polarity for said circuit, a rectifier connected in each of said coupling circuits, voltage regulating means including integrating means responsive to the carrier amplitude of said modulated-carrier signal for applying to the rectifier in one of said coupling circuits a gate voltage to limit the peaks of amplitude in the circuit of said rectifier at a cut-off level proportional to the carrier amplitude, means for applying a gate voltage to the rectifier in the other coupling circuit causing said rectifier to limit the peaks of amplitude in the said circuit at a cut-off level determined by the gate voltage on said rectifier, said direct and inverse circuits each providing substantial coupling and being so proportioned that the inverse cut-off level is beyond the direct cut-off level and the direct circuit provides the greater coupling for amplitudes below its cut-off level, whereby the peak of any pulse exceeding the direct cut-off level is inverted to the extent of the limit imposed by the inverse cut-off level.

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