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J. J. OKRENT

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AMPLITUDE-LIMITING SIGNAL-TRANSLATING CHANNEL

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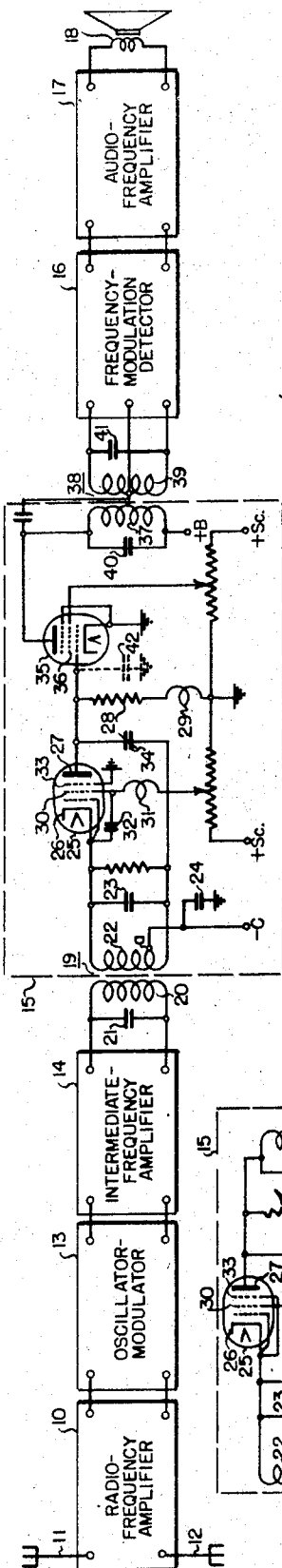


FIG. 1.

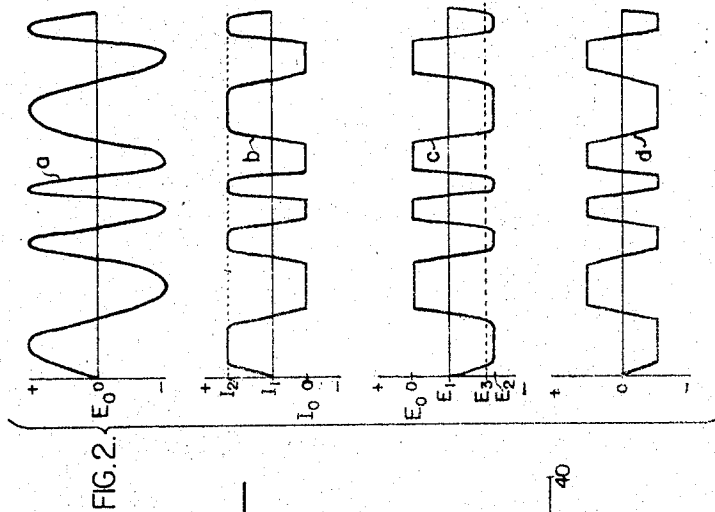


FIG. 2.

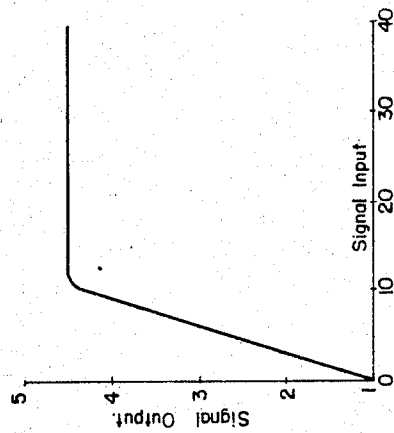


FIG. 3.

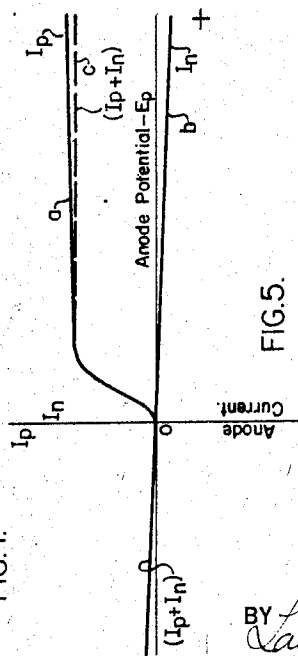


FIG. 4.

FIG. 5.

INVENTOR
JASPER J. OKRENT
BY *Laurence B. Dadds*
ATTORNEY

UNITED STATES PATENT OFFICE

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AMPLITUDE-LIMITING SIGNAL-TRANSLATING CHANNEL

Jasper J. Okrent, Great Neck, N. Y., assignor to
Hazeltine Corporation, a corporation of Delaware

Application May 28, 1940, Serial No. 337,653

13 Claims. (Cl. 178—44)

The present invention relates to improved signal-translating channels for signaling systems and, particularly, to signal-translating channels having amplitude-limiting transmission characteristics. While not limited thereto, the invention is especially suitable for use in frequency-modulation receivers to limit to a predetermined value the amplitude of translated carrier signals.

Signaling systems frequently require in their operation the use of amplitude-limiting systems for the purpose of maintaining substantially constant the amplitude of signals applied to a translating device of the system. An example of this occurs in frequency-modulation receivers wherein variations of amplitude of received carrier signals are detrimental to the proper operation of the receiver under certain conditions and, therefore, are preferably removed before the carrier signal is demodulated to derive the frequency-modulation components thereof. Amplitude limiters of this character should have no delay in responding to amplitude disturbances and, for ideal limiting, should have a substantially constant output over a wide range of input carrier-signal amplitudes. It has been recognized that an amplitude-limiting system possessing these necessary characteristics should be one which limits both half-cycles of the received carrier signal individually and preferably substantially equally.

In accordance with the foregoing requirements, it has been proposed that amplitude limiting be accomplished by the provision of a pair of tandem-connected signal repeaters operating individually to limit by anode current cutoff half-cycles of opposite polarity of the translated signal. An arrangement of this character has the disadvantage that the amplifier preceding the limiting system may be badly loaded at high input-signal levels by grid current of the first repeater of the limiting system. It has the further disadvantage that the grid current of the first amplifier of the limiting system is generally excessive, for the usual tubes employed, and the anode and screen-grid currents of the first repeater tube become excessive at high input-signal levels. Moreover, the cathode of the second repeater tube in systems of this type heretofore proposed is at a potential approximately that of the anode of the first tube, which causes an undue strain on the insulation between the cathode and cathode heater of the indirectly-heated type of vacuum tube. Additionally, the operating voltages of both repeater tubes are critical and must remain constant for constant limiting

operation, regardless of the input-signal level, although the operating currents vary over a wide range of values.

It has also been proposed that limiting be accomplished by limiting the amplitude of the half-cycles of one polarity of the input signal by the use of a diode rectifier and by limiting the half-cycles of opposite polarity by anode-current cutoff of a tandem-connected amplifier. This arrangement has the disadvantage that at the high carrier frequencies employed in frequency-modulation systems, the anode-cathode capacitance of the diode rectifier has a relatively small reactance and, therefore, signal currents of appreciable magnitude flow through the capacitive reactance of the diode to the succeeding amplifier, thereby impairing the limiting action.

Each of the foregoing proposed systems has the further disadvantage in certain applications in that a wide band coupling system must be employed between the two tubes of the limiting system to pass the wide frequency band necessary for the translation of the signal as changed in wave form by the amplitude-limiting operation. The constants of this coupling system are limited by the inherent capacitances of the two tubes and their associated circuits and by the band width necessary for faithful translation of the signal as distorted by the limiting action. These limitations are of such a nature that the input impedance and the coupling impedance of the prior art systems are generally so small that the gain of the limiting system and of the preceding signal amplifier is accordingly greatly reduced.

It is an object of the present invention, therefore, to provide a signal-translating channel having a new and improved limiting transmission characteristic which, while of general application, is especially suitable for use in frequency-modulation receivers and one which avoids one or more disadvantages of the prior art devices.

It is a further object of the invention to provide a limiter system of the type described having substantially no delay in its response to variations in the amplitude of signals translated through the system.

It is an additional object of the invention to provide a limiting system of the type described having high input impedance and one which, therefore, does not unduly load and thereby reduce the gain of the preceding signal amplifier.

In accordance with one embodiment of the invention, a signal-translating channel comprises an input circuit adapted to have applied thereto signals to be translated, an output circuit includ-

ing an impedance, means for translating signals of limited amplitude from the input circuit to the output circuit comprising a vacuum tube coupled between the input and output circuits to develop across the impedance signal potentials, and space-charge electrodes within the tube to limit the amplitudes of the half-cycles of one polarity of the developed potentials by current saturation of the tube. Means is provided for so biasing the tube that the amplitudes of the half-cycles of opposite polarity of the developed potentials are limited by current cutoff of the tube.

In a preferred form of the invention, there is additionally included repeating means including a vacuum tube coupled to the impedance for so repeating the developed signal potentials that the amplitudes of the half-cycles of the one polarity are further limited by anode current cutoff of the repeating tube substantially to the same amplitudes as the half-cycles of opposite polarity.

In a specific form of the invention, the vacuum tube which couples the input and output circuits has a grid interposed between its anode and cathode to reduce the inherent capacitance therebetween, thereby to reduce the capacitive coupling between the input and output circuits. There may additionally be provided means for applying to the output circuit signals of equal magnitude and opposite phase to signals applied to the output circuit through the inherent inter-electrode capacitance of the coupling tube, thereby to neutralize the latter.

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

Referring now to the drawing, Fig. 1 is a circuit diagram, partly schematic, of a complete frequency-modulated carrier-signal receiver embodying the invention; Fig. 2 is a graph representing potential and current waves occurring at various points in the signal-translating channel and is used in explaining the operation of the invention; Fig. 3 is a graph representing the limiting transmission characteristic of the Fig. 1 embodiment of the invention; Fig. 4 is a circuit diagram representing a modified form of the limiting system of the invention, per se; and Fig. 5 is a graph representing certain potential-current relations occurring in the Fig. 4 modification and is used in explaining the operation thereof.

Referring now more particularly to Fig. 1, there is represented schematically a complete frequency-modulated carrier-signal receiver of a conventional design embodying the present invention in a preferred form. In general, the receiver includes a tunable radio-frequency amplifier 10 having its input circuit connected to an antenna system 11, 12, and having its output circuit connected to an oscillator-modulator 13. Connected in cascade with the oscillator-modulator 13, in the order named, are an intermediate-frequency amplifier 14 of one or more stages, an intermediate-frequency signal-translating channel 15, more fully described hereinafter, a frequency-modulation detector 16, an audio-frequency amplifier 17 of one or more stages, and a sound reproducer 18.

It will be understood that the various units just described may, with the exception of the signal-translating channel 15, be of a conventional con-

struction and operation, the details of which are well known in the art, rendering further description thereof unnecessary. Considering briefly the operation of the receiver as a whole, and neglecting for the moment the operation of the signal-translating channel 15 presently to be described, a desired frequency-modulated carrier signal is selected and amplified by the radio-frequency amplifier 10, converted to a frequency-modulated intermediate-frequency carrier signal in the oscillator-modulator 13, amplified in the intermediate-frequency amplifier 14, limited to a predetermined substantially constant amplitude in the signal-translating channel 15; and detected by the frequency-modulation detector 16, thereby to derive the audio-frequency modulation components. The audio-frequency components are, in turn, amplified in the audio-frequency amplifier 17 and are reproduced by the sound reproducer 18 in a conventional manner.

Referring now more particularly to the portion of the system embodying the present invention, the signal-translating channel 15 has an input circuit comprising a transformer 19 having a primary winding 20 tuned to the mean intermediate frequency of the receiver by a condenser 21, and has a secondary winding 22 likewise tuned to the mean intermediate frequency by a condenser 23. The secondary winding 22 is tapped at a point *a* near its low-potential end and this tap is grounded by a by-pass condenser 24 and is connected to a source of negative biasing potential $-C$ of relatively small value. The portion of the transformer winding 22 above the tap *a* is connected to apply carrier signals through a unidirectional current-conducting device 25 to an output load circuit comprising a resistor 28 and inductor 29, in series. The unidirectional current-conducting device 25 is preferably a pentode type vacuum tube having a cathode 26 and control electrode connected directly thereto, a screen grid 30 and a suppressor grid 33. The screen grid 30 of tube 25 is connected to a source of operating potential $+Sc$ through a radio-frequency choke coil 31 and is by-passed to its cathode 26 through a condenser 32. The suppressor grid 33 is directly connected to ground. The several grids of tube 25 develop a space charge within the tube to limit the maximum value of anode current, thereby not only to protect the tube by limiting to a safe value the cathode emission but additionally to ensure a substantially constant value of anode current for values of anode potential greater than that necessary to produce anode current saturation. The portion of the winding 22 below the tap *a* is connected to apply neutralizing potentials through a small neutralizing condenser 34 to the anode of tube 25.

The load or output circuit 28, 29 of the rectifier tube 25 is coupled to the control grid of a repeater tube 35, the output circuit of which includes the primary winding 37 of an intermediate-frequency transformer 38. Tube 35 is also preferably of the pentode type and is provided with a screen grid 36 connected to a source of operating potential $+Sc$. The secondary winding 39 of transformer 38 is coupled to the frequency-modulation detector 16, the primary winding and the secondary winding of the transformer being tuned to the mean intermediate frequency of the receiver by the respective condensers 40 and 41.

The load circuit 28, 29 of the rectifier tube 25

includes capacitance 42, which is shown in dotted lines since it may be comprised in whole or in part by the inherent capacitance of the load circuit. The conductor 29 is proportioned with relation to the value of the resistor 28 and capacitance 42 to pass the broad band of frequencies necessary for faithful translation of the carrier signals as distorted by the limiting action.

In considering the operation of the circuit just described, it will be assumed that a frequency-modulated carrier signal having the wave form represented by curve *a* of Fig. 2 is applied through the transformer 19 to the signal-translating channel 15. The carrier-signal potentials appearing in the transformer secondary winding 22 between the point *a* and the high-potential terminal of the winding are applied in series with the bias source $-C$ to the output impedance 28, 29 through the anode-cathode circuit of tube 25. In the absence of any signal applied to the input circuit of the signal-translating channel 15, the unidirectional-bias potential $-C$ causes a constant flow of current through tube 25 as represented by the current I_1 of Fig. 2. The input-signal potential, therefore, combines with the unidirectional-bias potential to produce a resultant current flow represented by curve *b* of Fig. 2. The maximum value of this current is limited by the level of current saturation I_2 of tube 25, which is determined by the magnitude of the space-charge effect developed within the tube which, in turn, is determined in part by the magnitude of the potential applied to the grid 30, while the minimum amplitude is limited by anode current cutoff I_0 of tube 25, due to its unilaterally-conductive properties. The current through tube 25 produces across the output impedance 28, 29 a potential drop represented by curve *c* of Fig. 2, this potential varying about the axis E_1 , corresponding to the potential produced by the current I_1 , and having half-cycles of one polarity, the amplitudes E_2 of which are limited by anode current saturation I_2 of tube 25 and having half-cycles of opposite polarity, the amplitudes E_0 of which are smaller than the amplitudes of the half-cycles of the one polarity and are limited by anode current cutoff I_0 of tube 25. For purposes of convenience in further considering the operation of the invention, the half-cycles having the amplitude E_2 will be referred to as the half-cycles of "positive polarity"; similarly, the half-cycles of amplitude E_0 will be the half-cycles of "negative polarity."

As thus arranged, the vacuum tube 25 comprises means for translating signals of limited amplitude from the input circuit to the output circuit of the signal-translating channel 15. Further, it will be seen that this vacuum tube is arranged, in the particular embodiment of Fig. 1, with its anode-cathode path serially coupled between the input and output circuits to develop across the output circuit impedance 28, 29, 42 signal potentials. The screen grid 30 and suppressor grid 33 of tube 25 comprise space-charge electrodes within the tube to limit the amplitude of the half-cycles of one polarity of the developed potentials by current saturation of the tube, the source of operating potential $+Sc$ comprising means for biasing the screen grid 30 for this purpose. The bias source $-C$ comprises means for so biasing the tube that the amplitude of the half-cycles of opposite polarity of the developed potentials is limited by anode-current cutoff of the tube.

It has been stated that the amplitudes of the

half-cycles of positive polarity are limited by anode current saturation of tube 25. In practice, the magnitude of anode current saturation increases slightly with increasing values of input signal strength, the variation of increase being somewhat irregular when the suppressor grid is grounded, as in Fig. 1. For this reason, the amplitude of the half-cycles of positive polarity is not quite constant throughout the operating range of input signal strength and must be rendered constant by the limiting action of the tube 35.

The potential appearing across the output circuit impedance 28, 29 is, therefore, applied to the input electrodes of tube 35. The potential applied to the screen grid 36 of this tube is so proportioned with relation to the potentials developed across the output circuit impedance 28, 29 that tube 35 is driven to anode current cutoff at a level on curve *c* represented by the potential E_3 . Tube 35 thus repeats the signal potentials developed across the output circuit impedance 28, 29 but, in doing so, further limits by its anode current cutoff the amplitudes of the half-cycles of positive polarity. The repeated signal potential appearing in the secondary winding 39 of the output transformer 38 has a wave form represented by the curve *d* of Fig. 2, the amplitude of the positive and negative half-cycles of which is equal. The repeated carrier signals as thus limited are, of course, applied to the frequency detector 16 for demodulation to derive the audio-frequency modulation components thereof, as previously explained.

Fig. 3 is a graph representing the relation between the intensity of the carrier signals applied to the input of the signal-translating channel 15 and repeated carrier signals applied from the output of the signal-translating channel to the input of the detector 16. It will be seen that the output increases rapidly to the signal level at which limiting begins and thereafter remains substantially constant over a wide range of increasing values of input-signal strength.

From the foregoing explanation of the operation of the invention, it will be evident that the value of the unidirectional potential applied to the grid 30 of tube 25 determines the value of saturation current of this tube, thereby to determine the peak-to-peak amplitude of the plate current wave. Similarly, the value of unidirectional-bias potential $-C$ applied to the cathode 26 determines the value of current in the absence of applied carrier signals and thus determines the relative amplitudes of positive and negative half-cycles of the signal potential developed across the output circuit impedance 28, 29. The value of the cathode potential is preferably such that the half-cycles of positive polarity are limited to an amplitude slightly larger than the amplitude of the half-cycles of negative polarity.

When the half-cycles of positive polarity are thus limited, the accumulation of a large negative charge on the inherent capacitance 42 of the output circuit coupling impedance is avoided, thereby to permit the use of a larger resistor 28 consistent with the band of frequencies which must necessarily be passed by the output circuit coupling impedance comprising the inductor 29, the resistor 28, and the inherent capacitance 42. This is another way of expressing the fact that the wave shape of the limited carrier signal developed across the output circuit impedance varies less with change of input signal after limiting begins than would be the case were the

tube 25 so biased as to limit by current saturation at a higher current level since, when the positive and negative half-cycles have nearly equal amplitudes, the wave form of the signal developed across the output circuit impedance 28, 29 changes only slightly with changing values of input signal. The fidelity requirements of the output circuit impedance are accordingly reduced. Additionally, it is obvious that the larger the resistor 28 is made, the larger is the input impedance of the signal-translating channel 15 with the result that the preceding amplifier stage in the intermediate-frequency amplifier 14 is substantially less loaded.

The suppressor grid 33 of tube 25 is at ground potential and thereby provides an electrostatic shield between the anode and cathode of this tube. This greatly decreases the inherent inter-electrode capacitance between the anode and cathode, thereby to reduce the undesirable capacitive current which flows through tube 25 without limiting to the output circuit impedance 28, 29. The effect of the slight remaining anode-cathode inherent capacitance is further reduced by a neutralizing potential derived from the portion of winding 22 below the tap *a* and applied to the output circuit impedance 28, 29 through the adjustable neutralizing condenser 34. The condenser 34 is so adjusted that this neutralizing potential is of equal magnitude but opposite phase to the potential which is applied to the output circuit impedance by virtue of the inherent interelectrode capacitance of tube 25. Thus, the condenser 34 and the portion of the secondary winding 22 below the tap *a* comprise means coupled to the output circuit impedance 28, 29, 42 for applying thereto signals of equal magnitude and opposite phase to signals applied to the output circuit through the inherent inter-electrode capacitance of the tube 25, thereby to oppose the effect on the output circuit of the interelectrode capacitance.

As illustrative of a specific embodiment of the invention, the following circuit constants are given for the embodiment of the invention shown in Fig. 1:

Tube 25-----	Type 6SJ7
Tube 35-----	Type 6AC7
Condenser 23-----	130 micro-microfarads
Condenser 32-----	3,000 micro-microfarads
Condenser 34-----	5.8 micro-microfarads
Inductor 29-----	39 microhenries
Inductor 31-----	500 microhenries
Resistor 28-----	2,000 ohms
Transformer secondary winding 22-----	24 microhenries (universal wound coil of 25 turns, tapped at the third turn)
Mean intermediate frequency-----	2.7 megacycles
Cathode-potential tube 25-----	1.3 volts
Screen-potential tube 25-----	22.5 volts
Screen-potential tube 35-----	45 volts
Anode-potential tube 35-----	90 volts

Fig. 4 is a circuit diagram representing a modified form of the invention which is essentially similar to the embodiment of Fig. 1, and similar circuit elements are designated by similar reference characters. This modification is somewhat more simple than that of the Fig. 1 modification in that the repeater tube 35 of the Fig. 1 arrangement is dispensed with and the amplitudes of both positive and negative half-cycles of the translated carrier signals are limited by the use of a single tube. The anode of tube 25 is directly connected to the primary winding 37 of the output transformer 38, while the point *a* on the secondary winding 22 of the input transformer 19 is connected directly to ground. The suppressor grid 33 is connected directly to the cathode 26 to improve the linearity of the anode-

voltage current characteristic of this tube since, as previously pointed out in connection with Fig. 1, the characteristic is somewhat irregular when the suppressor grid is grounded. The operation of this embodiment is essentially similar to that of the Fig. 1 embodiment, carrier signals being translated through the translating channel 15 in such manner that the amplitudes of the half-cycles of positive polarity are limited by anode current saturation of tube 25, while the amplitudes of half-cycles of negative polarity are limited by anode current cutoff of tube 25, the operating potentials of tube 25 being so adjusted that the positive and negative half-cycles of the limited carrier signal have equal amplitudes.

The arrangement of Fig. 4 includes a resistor 43 connected in parallel with the neutralizing condenser 34. Fig. 5 is a graph wherein curve *a* represents the relation between the anode potential E_p of tube 25 and anode current I_p for values of applied anode potential of positive and negative polarity. It will be seen that the anode current increases slightly with increasingly large values of anode potential, whereby the limiting action decreases slightly on strong input signals. The signal potentials appearing between the point *a* and the low-potential terminal of the transformer winding 22 are applied through the resistor 43 to the output transformer primary winding 37, whereby there flows in the primary winding 37 signal currents, the magnitudes of which are represented by the curve *b*, which are opposite in phase to the signal currents through the tube 25 and are, therefore, shown in Fig. 5 as being equivalent to negative anode currents. The combined signal currents applied to the output transformer 38 thus add to produce a signal current, the intensity of which is substantially constant as represented by curve *c* of Fig. 5. Curve *c*, therefore, represents the transmission characteristic of the channel 15 and it is evident that the limiting action is substantially ideal over a wide range of input-signal amplitudes.

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

What is claimed is:

1. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube coupled between said input and output circuits to develop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, and means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by current cutoff of said tube.

2. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube coupled between said input and output circuits

to develop across said impedance signal potentials, said tube having a grid, means including said grid for developing a space charge within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, and means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube.

3. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to develop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, and means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube to substantially the same amplitude as half-cycles of said one polarity.

4. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to develop across said impedance signal potentials, said vacuum tube having a grid, means for biasing said grid to develop a space charge within said tube, whereby the amplitude of the half-cycles of one polarity of said developed potentials is limited by current saturation of said tube, and means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube.

5. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube coupled between said input and output circuits to develop across said impedance signal potentials, said vacuum tube having a screen grid, means for so biasing said screen grid that the amplitude of the half-cycles of one polarity of said developed potentials is limited by current saturation of said tube, and means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube.

6. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to develop across said impedance signal potentials, said tube having inherent interelectrode capacitance, means for developing a space charge within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current

saturation of said tube, means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube, and means coupled to said output circuit for applying thereto signals of equal magnitude and opposite phase to signals applied to said output circuit through the inherent interelectrode capacitance of said tube, thereby to oppose the effect on said output circuit of said interelectrode capacitance.

7. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to develop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube, and means coupled to said output circuit for applying thereto signals of relatively small magnitude and opposite phase to signals developed across said impedance by said coupling means, thereby to oppose variations in the amplitude of the signal transmitted by said coupling means with increasing values of signal amplitude applied to said input circuit.

8. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having a screen and suppressor grids and having an anode and a cathode serially-connected between said input and output circuits to develop across said impedance signal potentials, means including said grids for developing a space charge within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, and means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube.

9. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to develop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube, and means providing an electrostatic shield between the electrodes of said vacuum tube to reduce the inherent interelectrode capacitance thereof, thereby to reduce the capacitive coupling between said input and said output circuits.

10. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit includ-

ing an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having a cathode, an anode, and an interposed grid, the anode-cathode path of said tube serially coupling said input circuit to said output circuit to develop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, and means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube, said grid being at ground potential to reduce the inherent capacitance between said cathode and said anode, thereby to reduce the capacitance coupling between said input and said output circuits.

11. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to develop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube, the circuit constants of the translating means being relatively so proportioned that the amplitude of the half-cycles of said one polarity is larger than the amplitude of the half-cycles of said opposite polarity, and repeating means including a vacuum tube coupled to said impedance and biased so to repeat said developed signal potential that the amplitude of the half-cycles of said one polarity is further limited by anode current cutoff of said repeating tube.

12. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to de-

velop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube, the circuit constants of the translating means being relatively so proportioned that the amplitude of the half-cycles of said one polarity is larger than the amplitude of the half-cycles of said opposite polarity, and repeating means including a vacuum tube coupled to said impedance and biased so to repeat said developed signal potential that the amplitude of the half-cycles of said one polarity is further limited by anode current cutoff of said repeating tube to substantially the same amplitude as half-cycles of said opposite polarity.

13. A signal-translating channel comprising, an input circuit adapted to have applied thereto signals to be translated, an output circuit including an impedance, means for translating signals of limited amplitude from said input circuit to said output circuit comprising a vacuum tube having an anode-cathode path serially coupled between said input and output circuits to develop across said impedance signal potentials, space-charge electrodes within said tube to limit the amplitude of the half-cycles of one polarity of said developed potentials by current saturation of said tube, means for so biasing said tube that the amplitude of the half-cycles of opposite polarity of said developed potentials is limited by anode current cutoff of said tube, the circuit constants of the translating means being relatively so proportioned that the amplitude of the half-cycles of said one polarity is larger than the amplitude of the half-cycles of said opposite polarity, repeating means including a vacuum tube having a screen grid and having input electrodes coupled to said impedance for repeating said developed signal potentials, and means for applying to said screen grid an operating potential the magnitude of which is so proportioned with relation to the potentials developed across said impedance that the amplitude of the half-cycles of said one polarity is further limited by anode current cutoff of said repeating tube substantially to the amplitude of the half-cycles of said opposite polarity.

JASPER J. OKRENT.

CERTIFICATE OF CORRECTION.

Patent No. 2,271,203.

January 27, 1942.

JASPER J. OKRENT.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 4, for "conductor" read --inductor--; page 5, first column, line 52, claim 5, after "tube" insert the following words --having an anode-cathode path serially--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of June, A. D. 1942.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)