

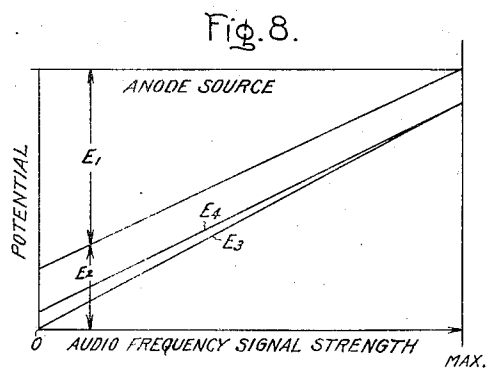
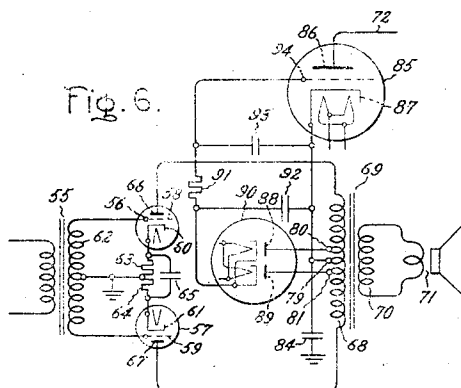
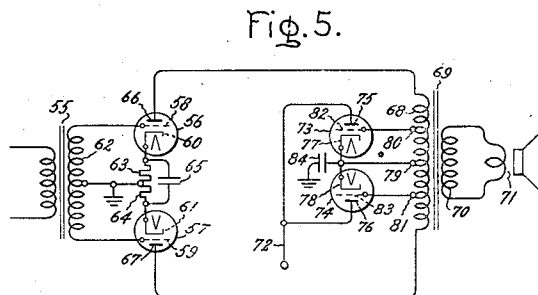
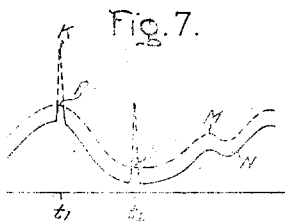
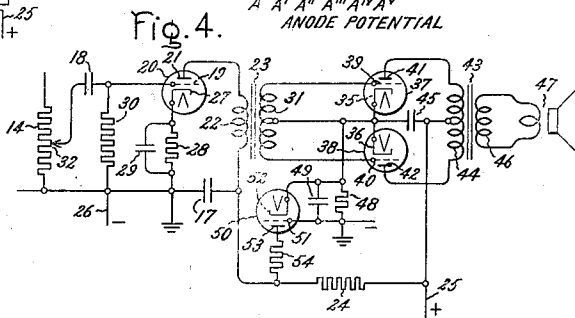
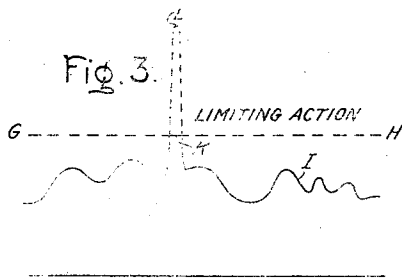
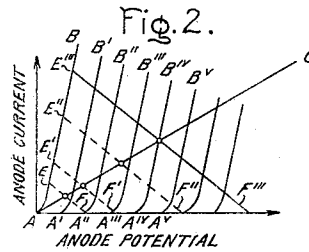
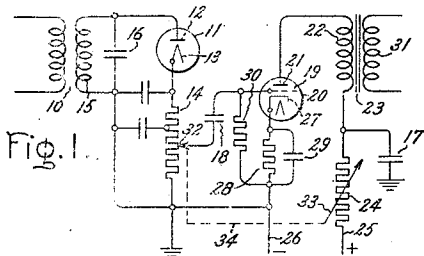
March 18, 1941.

G. W. FYLER

2,235,550

AMPLIFIER

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UNITED STATES PATENT OFFICE

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AMPLIFIER

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11 Claims. (Cl. 179—171)

My invention relates to signal amplifiers and more particularly to an improved signal amplifier arrangement which operates to reduce the effect in the amplifier output circuit of static and transient noise impulses which may be supplied with signal oscillations to the input circuit of the amplifier.

The present trend in amplifier design is toward greater amplifier output for a given signal input with a given type of electron discharge device. This is especially true in the present day design of radio receiver amplifiers. In the past, when the output of receivers was only slightly more than the level at which a normal person would care to listen to a program and an abnormal amount of transient noise impulses originated in or was supplied to the input circuit of a receiver, it was not amplified beyond the limited extent of the available range of the receiver amplifier. Furthermore, the frequency response of the prior art receivers was in general quite limited. With the extended low and high frequency response now obtainable in a receiver having a maximum sound output of perhaps 20 to 50 watts, there is the very great possibility of producing large sound outputs of undesirable high frequency noise components when a person is listening to a signal at a low wattage level and a transient or static crash impulse excites to full power output the audio amplifier of the receiver.

An object of my invention is to provide in a signalling apparatus an amplifier arrangement capable of producing a maximum of undistorted signal output with a minimum amount of high frequency transient noise output.

A further object of my invention is to provide an amplifier of an improved and simplified design which, in operation, greatly reduces the disturbing effects of static and the like transient disturbances, and one having an improved performance with increased economy of operation.

Another object of my invention is to provide in an amplifier a control circuit for controlling concurrently both the anode and the grid biasing potentials supplied to an electron discharge device included in the amplifier thereby to control and limit the maximum amplitude of both signal oscillations and transient noise peaks which pass through the amplifier stage, and my invention contemplates that a component of the amplifier output signal may itself determine and control the amplifier in a manner to limit the amplitude of transient noise peaks to that of the maximum amplitude of the signal oscillations at a given time.

A further object of my invention is to provide in an amplifier a control circuit arrangement by which the anode potential supplied to an electron discharge device included in the amplifier is controlled in a manner to change the potential either by manual means or by automatic means or by both manual and automatic means in direct proportion to changes in the strength of signals supplied to the input circuit of the amplifier.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 illustrates an embodiment of my invention; Figs. 2 and 3 are graphs used in explanation of the operation of this embodiment of my invention; Figs. 4, 5, and 6 are modifications of my invention, and Figs. 7 and 8 are graphs used in explanation of the operation of these modifications.

Referring particularly to Fig. 1 of the drawing, my invention is illustrated as embodied in the first stage of audio frequency amplification of a signalling apparatus. Modulated radio frequency oscillations are supplied through an input transformer 10 to an electron discharge diode rectifier 11. The device 11 has an anode 12 and a cathode 13 connected in series circuit including a load resistor 14 and a secondary winding 15 of the transformer 10. A condenser 16 tunes the secondary winding 15 of the transformer 10 to the frequency of the input signal oscillations.

The diode 11 rectifies the modulated radio frequency oscillations supplied through the transformer 10 and the modulation components appear as alternating potentials superimposed upon a unidirectional potential across the diode load resistor 14. A portion of the alternating current potential is supplied through a condenser 18 to a control grid 19 of an electron discharge device 20. The device 20 has an anode 21 connected in an output circuit which includes the primary winding 22 of an audio frequency transformer 23, a variable resistor 24, a by-pass condenser 17, and a source of anode potential, not shown, whose positive terminal is connected to the conductor 25 and whose negative terminal is connected to the conductor 26. The device 20 additionally includes a cathode 27 which is connected to the conductor 26 through a parallel

connected cathode biasing resistor 23 and condenser 29. The flow of anode current through the device 20 produces a unidirectional biasing potential across the resistor 28 which is supplied through a resistor 30 to provide a negative bias for the grid 19. A secondary winding 31 of the audio frequency transformer 23 is connected to additional apparatus, not shown, which may include additional stages of audio frequency amplification and a translating device.

The operation of this embodiment of my invention will now be explained by the aid of Figs. 2 and 3 of the drawing. Fig. 2 illustrates graphically the characteristic curves of the electron discharge device 20 employed in my audio frequency stage of amplification and shows the anode current of the discharge device plotted as ordinates with the anode voltage plotted as abscissas. The several curves AB, A'B', etc., represent the relation between the anode current and the anode potential for the discharge device for varying values of negative biasing potential supplied to its control grid 19. The curve AB is for a zero bias while the curves A'B', etc., represent the anode current and potential relations for increasingly equal increments of negative bias supplied to the grid. Since the potential drop across the resistor 28 varies in direct proportion to the anode current, the curve AC of Fig. 2 represents the locus of the grid biasing potentials as a function of the potential supplied to the anode 21 of the device 20. The lines EF, E'F', etc., represent in a manner well known in the art the load lines for the discharge device 20, the slope of the load lines being a function of the output circuit impedance determined by the particular electron discharge device employed in the amplifier circuit. The anode swing of the device 20 is limited to the length of the line EF, E'F', etc. (the length of which is a function of the anode potential), being limited at the axis of abscissa by the anode current cut-off and at the line AB by grid current flowing through the resistor 30, the grid current limiting the grid potential. It can be shown that the correct bias on the grid 19 to provide equal anode swings about the line AC of Fig. 2 is substantially maintained for wide variations of the plate potential by the use of the cathode biasing resistor 28 and parallel connected condenser 29.

It will now be evident that by changing the value of the anode circuit resistor 24, the anode potential supplied to the anode 21 of the device 20 may be controlled at will to control the length of the load line EF, E'F', etc., thereby to limit the maximum amplitude of signal or noise oscillations which may pass from the input to the output circuit of the discharge device 20. Referring to Fig. 3, the broken line GH represents the maximum amplitude which signal or noise oscillations may have for a particular setting of the resistor 24. If the amplitude represented by the line GH is sufficiently high that the signal oscillations, whose envelope is represented by a solid line I, do not exceed the amplitude GH, then the signal oscillations will be faithfully reproduced in the output circuit of the amplifier. However, when a transient noise impulse, represented by Fig. 3 by the curve L, is supplied with the signal oscillations to the input circuit of the amplifier, the maximum amplitude of the noise impulse occurring in the output circuit of the amplifier is limited to the amplitude GH, as shown by K. If it were not for the amplitude limiting action of the amplifier stage, the noise impulse would appear

in the output circuit of the amplifier with an amplitude L greatly in excess of the maximum amplitude of the signal oscillations and would be reproduced in a loud speaker connected to the output of the amplifier as a loud burst or crash of static. The effect of transient noise impulses of this nature is thus effectively reduced by the limiting action of an amplifier constructed in accordance with my invention.

In the preferred embodiment of my invention the movable arm 32, which contacts the load resistor 14, and the movable arm 33, which changes the value of the resistance of the resistor 24, are mechanically connected together for unicontrol operation. This mechanical interconnection of these controls is indicated in Fig. 1 by the broken line 34. The mechanical connection is such that movements of the contact 32 to the upper end of the resistor 14, to increase the audio output of the amplifier, is accompanied by a corresponding decrease in the value of the resistor 24 thereby to effect an increase in the magnitude of the potential supplied to the anode 21 of the device 20. The length of the load line EF is thus automatically increased as the strength of the signal oscillations supplied to the control grid 19 of the device 20 is increased by movement of the contact 22 to the upper end of the resistor 14 with the result that the signal oscillations are faithfully reproduced without distortion in the output circuit of the amplifier, yet the transient noise impulses are limited to the maximum amplitude of the signal oscillations supplied to the amplifier stage. Where the received signal is subject to fading, the automatic volume control of the high frequency amplifier, not shown, but which precedes the audio frequency amplifier stage, shown, should have a rather flat characteristic for optimum noise reduction.

Fig. 4 represents a modification of my invention in which elements corresponding to like elements of Fig. 1 are designated by like reference characters. In this modification, the secondary 31 of the audio frequency transformer 23 is center tapped, the center tap being connected to the cathode 35 and the cathode 36 respectively of a pair of electron discharge devices 37, 38. The outer terminals of the winding 31 are each respectively connected to a control grid 39, 40 of the discharge devices 37, 38. The discharge devices 37, 38 have respective anodes 41, 42 which are connected to the output audio frequency transformer 43 to provide a push-pull stage of amplification in a manner well known in the art. Anode potential is supplied to the anodes 41 and 42 by a connection of the conductor 25 to the center tap of the primary winding 44 of the transformer 43. A condenser 45 maintains the center tap of the winding 44 at cathode potential for currents of audio frequencies. The secondary winding 46 of the transformer 43 is connected to a translating device 47, here shown by way of example as a loud speaker.

The cathodes 35 and 36 of the respective discharge devices 37, 38 are connected to the negative terminal 26 of the anode potential supply through a resistor 48. A condenser 49 is connected in shunt to the resistor 48, the condenser 49 having a capacity to provide a low impedance in comparison to that of the resistor at twice the lowest audio frequency supplied to the amplifier, and yet to have a high impedance at syllabic frequencies. By syllabic frequencies are meant that range of frequencies from zero to approximately 30 cycles per second, which fre-

quency range is substantially that of the occurrence of the syllables in ordinary speech. It will be recognized that this range of frequencies is below the range occupied by voice and music frequencies.

An additional electron discharge device 50 has a control grid 51 and a cathode 52 connected across the terminals of the resistor 48. The device 50 has an anode 53 to which anode potential is supplied through the resistor 24 and a resistor 54.

The operation of this embodiment of my invention will now be considered. The potential which appears across the resistor 48 and parallel connected condenser 49 has a direct current component and an alternating current component of syllabic frequency. This potential controls the bias of the grid 51 of the device 50 thereby to control the anode current consumed by this device through the resistors 54 and 24 from the positive terminal 25 of the anode potential supply. It will be recognized that the electron discharge devices 37 and 38 are connected in well known manner as a class B power amplifier whose average anode current increases approximately linearly with increases of input signal strength. During periods of low signal strength, the average anode current of the power amplifier is relatively small and the control grid 51 of the device 50 consequently has a small negative bias. The anode current of the device 50 at this time is relatively large and in flowing through the resistor 24 produces across this resistor a large voltage drop which in turn greatly reduces the anode potential supplied to the anode 21 of the electron discharge device 20. The length of the load line EF (Fig. 2) for the device 20 is therefore greatly decreased during periods of low modulation of the received signal or low audio volume. The reduction of the permissible anode swings of the device 20 as in the Fig. 1 arrangement, though in an entirely automatic manner, accomplishes the reduction of the maximum amplitude of oscillations which may pass through the first stage of audio frequency amplification to provide during soft passages of a musical score or during lulls in the program a condition of quiet reception.

As soon as the strength of the audio signal increases, the anode current of the discharge devices 37, 38 correspondingly increases to cause an increase in the magnitude of the potential appearing across the resistor 48. The grid 51 of the device 50 thereupon is biased more negatively to effect an increase in the anode to cathode impedance of the device 50 and a decrease in the value of its anode current. The decreased anode current results in a corresponding decrease in the potential drop appearing across the resistor 24 with the result that the anode potential supplied to the anode 21 of the device 20 increases and the length of the load line EF for this device becomes longer. The stronger audio frequency signal oscillations thereupon appear reproduced without distortion in the anode circuit of the device 20. It is possible by a suitable choice of values for the resistors 24 and 54 for use with the particular electron discharge devices employed to obtain at all times an automatically varying threshold of limiting just above the peak amplitudes of the audio signal. This choice of values may readily be made by one skilled in the art.

The automatic change in the amplitude of the limiting action of the Fig. 4 arrangement is illus-

trated graphically in Fig. 7. The broken line M represents the instantaneous limiting action and therefore the maximum amplitude of oscillations which may appear in the output circuit of the device 20. The extent of this limiting action varies, of course, with the strength at any given instant of the syllabic frequency component appearing across the resistor 48 in the output circuit of the devices 37 and 38. The envelope of the syllabic frequency component is represented in Fig. 7 by the solid line N. A transient static impulse occurring at the time t_1 is limited in amplitude to the value P. Without the limiting action, this static impulse would appear in the output circuit with the amplitude K. A second transient signal impulse appearing at the time t_2 is limited to a smaller amplitude S since the strength of the syllabic frequencies appearing in the output circuit at the time t_2 is smaller than at the time t_1 . It will thus be evident that an amplifier constructed in accordance with this embodiment of my invention faithfully reproduces all of the signal oscillations (with the exception of the first few oscillations at the beginning of a syllable which, in practice, I have found does not impair the quality of either speech or music) while at the same time greatly reducing during quiet periods in the radio program the effects in the receiver output of the transient static impulses.

Fig. 5 illustrates an additional modification of my invention. In this modification, the audio frequency signal oscillations are supplied through an input audio frequency transformer 55 to a pair of electron discharge devices 56, 57 whose respective grid electrodes 58, 59 and cathodes 60, 61 are connected in push-pull manner to the secondary 62 of the transformer. A respective cathode biasing resistor 63, 64 is included in the cathode circuit of each of the devices 56, 57 to provide a negative bias for the respective control grids 58, 59. These devices operate as class A amplifiers. The resistors 63, 64 are equal (or adjustable) and permit each of the devices 56, 67 to self-bias itself correctly so that the anode currents are more readily balanced for hum and distortion cancellation. Each tube as thus connected and biased operates along the curve AC of Fig. 2 in the manner of the device 20 of the Figs. 1 and 4 arrangements. A condenser 65 by-passes the cathode resistors 63, 64 for audio frequencies to prevent audio degeneration and to allow rapid syllabic changes in the cathode bias potential. Individual by-pass condensers for the resistors 63 and 64 may be used if desired. The anodes 66, 67 of the respective devices 56, 57 are connected to the end terminals of a primary winding 68 provided in an output transformer 69. The transformer 69 has a secondary winding 70 which is connected to a translating device 71, here shown by way of example as a loud speaker.

The positive terminal of a source of anode potential, not shown, is connected to the conductor 72, the negative terminal of the source being grounded. A pair of electron discharge devices 73, 74 have their respective anodes 75, 76 connected together to the conductor 72. The respective cathodes 77, 78 of these devices are likewise connected together and to a center tap 79 provided on the primary winding 68 of the transformer 69. The primary winding 68 additionally has a pair of taps 80, 81 equally spaced on alternate sides of the center tap 79. The transformer tap 80 is connected to the control grid 82 of the

device 73 while the tap 81 is connected to the control grid 83 of the device 74. A condenser 84 maintains the cathodes 77, 78 and the center tap 79 of the transformer winding 68 at ground potential for alternating currents of audible frequency but allows syllabic variation of the anode potential at this point.

The operation of this embodiment of my invention is somewhat similar to that of the Fig. 4 arrangement except that the change in anode potential for the limiting audio frequency amplifier is accomplished by a variable impedance of the electronic type connected in series with the anode supply. The electron discharge devices 73 and 74 are preferably high mu tubes used as class B audio power amplifiers. Their plate impedance changes rapidly with changes in grid potential. The control grids 82, 83 of these devices are excited by the potentials appearing between the respective taps 79, 80 and 79, 81 provided on the primary winding 68 of the transformer 69. The signal potential at every instant causes the anode current of the device 56 to vary in an opposite manner to that of the device 57. Suppose, for example, that the input signal potential produces an instantaneous increase in the anode current of the device 56. The same potential causes the anode current of the device 57 instantaneously to decrease. The decreased value of anode current in the latter device operates to increase in a positive direction the instantaneous bias on the grid 83 of the device 74 thereby to decrease its anode-cathode impedance. A larger anode current now flows through the device 74 to supply the increased instantaneous value of anode current required by the device 56. Thus instantaneous increases of anode current required by the device 56 are supplied through the device 74 while increases in the anode current of the device 57 are supplied through the device 73.

It should be noted, however, that the average bias on the grids 82 and 83 of the respective devices 73 and 74 is determined by the average unipotential drop between the points 79 and 80, and between the points 79 and 81 of the transformer winding which in turn depends upon the average current through the devices 56 and 57. The latter is determined by the potential drop across the cathode resistors 63, 64 and parallel connected condenser 65. Since this potential drop varies at syllabic frequency, the average bias on the grids 82 and 83, and therefore the average impedance of the devices 73 and 74, likewise varies at syllabic frequency to produce variations at syllabic frequency in the value of the average anode potential supplied to the devices 56, 57. In other respects, the operation of this embodiment of my invention is similar to that of the Fig. 4 arrangement. The discharge devices 56, 57 operate along the curve AC of Fig. 2 to provide a limiting operation which may be represented by the graph of Fig. 7.

The relation between the potential drop across the devices 73 and 74 and the devices 56, 57 is illustrated graphically in Fig. 8. The average potential drop across the devices 73, 74 is represented in this figure as the potential E_1 . The average anode potential supplied to the devices 56, 57 is represented by the potential E_2 . As explained above and illustrated in this figure, the magnitude of the potentials E_1 and E_2 changes with change of the input signal strength. The sum of the potentials E_1 and E_2 , neglecting the small bias voltage drop across the resistors 63 and 64 for a given input signal strength must, of

course, equal the potential of the anode source which is assumed constant. The relation between the strength of the amplified signal oscillations supplied to the loud speaker 71 and the strength of the input signal oscillations is given by the line E_3 of Fig. 8, while E_4 represents the relation between the input signal strength and the maximum output of the amplifier as thus limited.

Fig. 6 illustrates a modification of the Fig. 5 circuit arrangement wherein elements corresponding to like elements of Fig. 5 are represented by like reference characters. A single high-mu electron discharge device 85, having similar operating characteristics to the electron discharge devices 73 or 74 of Fig. 5, has an anode 86 connected to the positive conductor 72 and a cathode 87 connected to the center tap 79 of the primary winding 68 of the output transformer 69. The taps 80 and 81 of the winding 68 are connected respectively through unidirectional conducting devices, here shown by way of illustration as the anode and cathode elements 88, 89 of an electron discharge diode rectifier 90 and through a filter comprised by the resistor 91 and the condensers 92, 93 to the control grid 94 of the device 85. The filter 91, 92 and 93 is arranged to filter from the potential supplied to the grid 94 all potentials having a frequency higher than the syllabic range of frequencies. The double diode rectifier 90 has the advantage that it doubles the lowest audio frequency signal components.

The control potential supplied to the grid 94 of the device 85 through the rectifier 90 from the primary winding 68 of the output transformer 69 controls the anode to cathode impedance of the device 85 thereby to control the magnitude of the anode potential supplied to the anodes 66 and 67 of the respective electron discharge devices 56, 57. The operation of this modification of my invention differs from the operation of the Fig. 5 arrangement only in the method of controlling the impedance of the electronic device included between the conductor 72 and the center tap 79 of the transformer winding 68.

While I have shown my invention as embodied in an audio frequency stage of amplification, it will be apparent to one skilled in the art that my invention is equally well suited for embodiment in a stage of radio frequency amplification. Thus, while I have illustrated particular embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto since many modifications may be made in the elements employed and in their arrangement, and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An amplifier, comprising an electron discharge device having an anode, a cathode, and a grid, a source of variable signal electromotive force connected between said grid and cathode, an output circuit connected between said anode and cathode, said source including noise electromotive forces to be limited in said amplifier, means to supply negative bias potential to said grid and positive operating potential to said anode, and means to increase and decrease both said bias potential and anode operating potential simultaneously in response to corresponding increase and decrease in intensity of said signal electromotive force whereby the amplitude range capability of said amplifier is varied in accordance

with the intensity of signal currents to be amplified and noise currents are limited to the instant amplitude capability of said amplifier.

2. An amplifier, comprising an electron discharge device having an anode, a cathode, and a grid, a source of variable signal electromotive force connected between said grid and cathode, said electromotive force having frequencies extending over a wide portion of the audio range including syllabic frequencies, and including noise electromotive forces to be limited in said amplifier, an output circuit between said anode and cathode, means to supply negative bias potential to said grid and operating potential to said anode, and means responsive to the intensity of the syllabic frequency component of said signal electromotive force to increase and decrease said bias and operating potentials as said component increases and decreases thereby correspondingly to vary the amplitude range capability of said amplifier, whereby said noise electromotive forces are limited by said amplitude range capability of said amplifier to values varying in accordance with the intensity of said syllabic component.

3. An electron discharge amplifier having an anode, a cathode, and a grid, a source of signal and noise currents connected between said grid and cathode, an output circuit connected between said anode and cathode, means to supply negative bias voltage to said grid and anode operating voltage to said anode, noise electromotive forces applied between said grid and cathode being limited during one-half cycle by substantially zero anode current and during the opposite half-cycle by current in said grid circuit, and means to increase and decrease said bias voltage and anode operating voltage in accordance with increase and decrease in said signal currents to be amplified whereby during amplification of weak signal currents weak noise currents are limited whereas during amplification of strong signal currents only strong noise currents are limited.

4. An amplifier, having an anode, a cathode, and a grid, a signal input circuit connected between said grid and cathode, a signal output circuit connected between said anode and cathode, a resistance common to said circuits upon which a bias for said grid is developed having a value dependent upon the unidirectional current in said anode circuit, and means to vary said anode current in response to, and in proportionate relationship to, the intensity of signal current amplified by said amplifier thereby to vary the amplitude range capability of said amplifier in accordance with the intensity of said signal current and to limit in said amplifier undesired currents of intensity greater than the intensity of said signal currents.

5. In a signalling system, the combination of a signal amplifier including an electron discharge device having an anode, a source of anode potential, means for limiting the maximum output of said amplifier in direct proportion to the magnitude of potential supplied from said source to said anode, means for controlling the strength of signals supplied to the input of said amplifier, means including a variable impedance for controlling the magnitude of the potential supplied from said source to said anode, and means connecting said last two named means for concurrent operation in a manner to increase the magnitude of said potential as said input signal strength is increased.

6. An amplifier having an anode, a cathode, and a grid, a source of signal currents of variable

intensity connected in circuit between said grid and cathode, a source of operating potential connected in circuit between said anode and cathode through a variable resistance, a resistance common to said circuits to develop a bias for said grid proportional to the unidirectional current between said anode and cathode, and means to vary in unison and in opposite relationship the intensity of said signal currents and the value of said resistance.

7. In a signal amplifier, the combination of a pair of push-pull connected electron discharge devices each having elements including an anode, a source of anode potential, means responsive to the magnitude of potential supplied from said source to said anode for limiting the output of said amplifier, an output impedance having a center tap and end terminals, said terminals being connected to a respective one of said anodes, a second pair of electron discharge devices, means for supplying anode potential from said source through said last named electron discharge devices in parallel to the center tap of said impedance, and means for controlling in accordance with the syllabic frequency of an input signal the impedance of said last named devices thereby to control the anode potential supplied from said source to the anodes of said first named devices.

8. The combination, in a signalling system, of a pair of push-pull connected electron discharge devices each having an anode, a cathode and a grid, means including a cathode resistor for supplying a negative bias to each of said grids, an output impedance having a center tap and end terminals, said end terminals being connected to a respective one of said anodes, a third electron discharge device having elements including an anode and a cathode, a source of anode potential, means including a connection from said source to said last named anode and from said last named cathode to said center tap for supplying potential from said source through the anode to cathode discharge path of said last named device to the anodes of said first named devices, and means for controlling in accordance with the syllabic frequency of an input signal the anode to cathode impedance of said last named device thereby to control the potential supplied from said source to the anodes of said first named devices.

9. An amplifier having an anode, a cathode and a grid, a source of signal currents of variable intensity connected in circuit between said grid and cathode, a source of operating potential connected in circuit between said anode and cathode through a resistance, a second resistance common to said circuits to develop a bias on said grid proportional to the unidirectional current between said anode and cathode, and means responsive to increase and decrease in intensity of signal current in said amplifier to decrease and increase respectively the current in said first resistance thereby to vary the unidirectional current flowing between said anode and cathode and through said second resistance to maintain the amplitude range capability of said amplifier just greater than said signal currents as said signal currents vary, thereby to limit noise currents in said signal source which exceed said amplitude range capability.

10. In combination, a two stage electron discharge grid-controlled signal amplifier, the first of said stages having a grid bias varying as the unidirectional current between the anode and cathode of said stage, and the second of said

stages having an anode current varying in intensity in proportion to the intensity of the signal current amplified by said amplifier, and means responsive to the anode current in said second stage to vary the anode operating potential of said first stage to maintain the amplitude range capability of said first stage just greater than the amplitude range of signal current amplified thereby whereby noise currents exceeding said range by more than a predetermined amount are limited by said first stage of said amplifier.

11. In combination, an electron discharge signal current amplifier, having a grid, an anode, and a cathode, a signal input circuit connected between said grid and cathode, having varying

signal and noise currents therein, an output transformer connected in circuit between said anode and cathode, a resistance common to said circuits to develop a bias on said grid which increases as the operating potential on said anode increases, and means responsive to the voltage across a portion of said output transformer to vary said operating potential to maintain the amplitude range capability of said amplifier just greater than the amplitude range of signal currents in said input whereby undesired currents in said input which exceed said range are limited in said amplifier.

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