

April 16, 1946.

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2,398,596

LIMITER CIRCUIT

Filed March 24, 1943

Fig. 1.

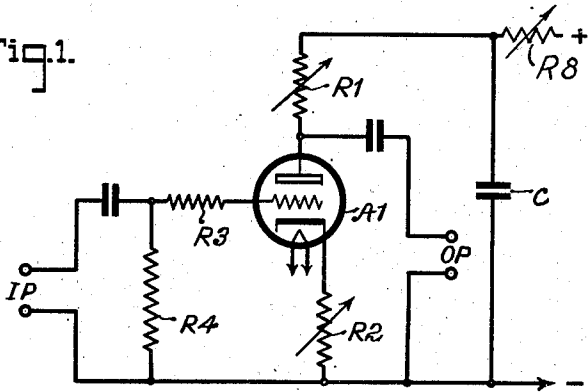


Fig. 2.

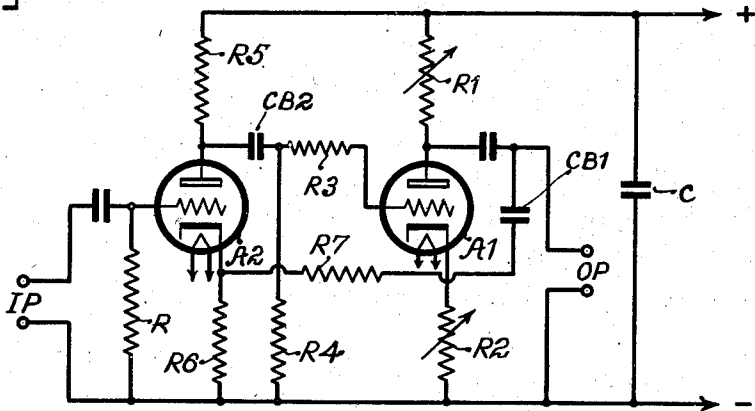
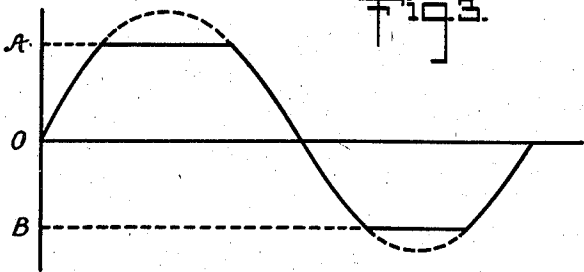


Fig. 3.



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2,398,596

LIMITER CIRCUIT

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Application March 24, 1943, Serial No. 480,343
In Great Britain January 16, 1942

2 Claims. (Cl. 178-44)

The present invention relates to thermionic circuit arrangements, and particularly to limiter arrangements therefor.

It is frequently required that there shall be a linear relationship between the input signal and output signal of a thermionic valve circuit for all values of input signal up to a given amplitude thereof, and that for values of input signal above the given amplitude there shall be no further increase in the value of the output signal. That is, that the output shall be limited. There are, of course, a number of circuit arrangements designed to satisfy this requirement, but, so far as my experience goes, they suffer from the defect that appreciable and objectionable distortion occurs before the point is reached at which limitation of the output occurs. What is really a different aspect of the same phenomenon, limitation of output takes place at a point which is undesirably higher than the point at which troublesome distortion occurs.

It is an object of the present invention to effect improvements in limiter arrangements for thermionic valve circuits.

According to this invention a thermionic valve circuit arrangement includes a thermionic valve, having an anode, control grid and cathode, connected between the positive and negative terminals of a source of anode current. The circuit includes a first impedance in the connection between the positive terminal and anode, a second impedance in the connection between the cathode and negative terminal, series-connected third and fourth impedances connected between the control grid of the valve and the negative terminal, connections whereby an input signal may be applied across the fourth impedance between the junction point of said third and fourth impedances and the negative terminal, and connections whereby an output signal may be taken from across the series-connected anode to cathode space of the valve and the second impedance. The values of the first and second impedances are such that for an input signal of given voltage, grid current just does not flow, but for an input signal of voltage higher than said given voltage, grid current flows in said second, third, and fourth impedances in such direction as to increase the effective negative bias of the control grid due to the flow of anode current in the second impedance. Moreover, the values of the third and fourth impedances are such that the grid current causes a very sharp discontinuity in the change in anode current.

The third impedance may be given such value

that the grid current has negligible effect upon the input circuit. The first and second impedances may be given such values that the half-cycle of input signal voltage which sweeps the anode current negatively will, by reason of the coupling of the grid and anode circuits in the second impedance, greatly reduce distortion effects until such an input signal voltage is applied that the falling anode current is too low for the prevailing degree of feedback to effect appreciable correction, so that sharp limitation occurs in this half-cycle also.

By a suitable choice of the values of the various components, particularly of the values of the impedances, the two limiting actions may be made to occur substantially symmetrically upon the positive and negative sides of a mean value of input signal voltage.

Figure 1 of the accompanying drawing illustrates a circuit arrangement according to the invention. Figure 2 shows a modification. Figure 3 graphically shows the operation of the circuit embodying the invention. In the circuit arrangement of Figure 1, there is connected between the positive terminal of a source of direct current and the anode of a valve A1, having an anode, control grid and cathode, an adjustable resistance R1. Between the cathode of the valve and the negative terminal of the current source there is connected a second adjustable resistance R2. A reservoir or decoupling condenser C is connected across the said current source; that is, from the positive end of the first resistance to the negative end of the second resistance. A third resistance R3 is connected at one end of it to the control grid of the valve, and at the other end of it to one end of a fourth resistance R4. The other end of the fourth resistance R4 is connected to the said negative terminal. An input circuit IP is connected across resistance R4, and an output circuit OP is connected across the anode to cathode space of the valve in series with resistance R2.

Resistance R2 effects a coupling between the anode to cathode circuit of the valve and the grid to cathode circuit, and also, provides for negative feedback. By suitably choosing the values of resistances R1 and R2 it is possible to obtain the condition that a given sinusoidal input signal voltage having an amplitude v will be just below that value at which grid current flows, but sweeps the anode current flow into the bent portion of the bottom of the anode current-grid voltage characteristic. Signal levels of amplitude greater than v will cause grid current to

flow through resistances R3, R2 and R4 in such a direction as to increase the negative grid bias voltage obtained by the flow of anode current through the resistance R2. If resistances R3 and R4 be given suitable values this flow of grid current will cause a very sharp discontinuity in the change of anode current. Further, if resistance R3 be given a suitable value this grid current can be made to have negligible effect on the circuit which supplies the input voltage v .

If, also, the resistances R1 and R2 be suitably chosen the half-cycle of input signal voltage which sweeps the anode current negatively will, by virtue of the coupling of the grid and anode circuits in resistance R2, experience the purifying effect of the feedback principle which is brought into play in such a circuit arrangement. During this half-cycle, therefore, distortion of the form of the input wave is greatly reduced until such an input signal voltage is applied that the falling anode current is too low for the prevailing degree of feedback to effect appreciable correction. Sharp limitation, then, is also produced for this half-cycle. By a suitable choice of the component values it is possible to arrange that the two limiting actions occur, as indicated in Figure 3, for closely equal amplitudes of positive and negative half-cycles, and that the distortion of the form of the output wave of voltage V is negligible until limiting occurs. This good limiting action can be obtained over a wide range of frequencies of input voltage.

A formula to express the required condition for symmetrical limitation of amplitude of output signals to some prescribed value can be stated. If for the above-described circuit a peak voltage v , applied to the control grid of the valve, is to produce the maximum amplitude of undistorted output signal, beyond which limitation, and therefore distortion occurs, then v must equal V , where V is the steady negative bias voltage applied to the grid. Furthermore, the values of the components must be so chosen that an anode current I flowing with a steady grid bias voltage V should be exactly doubled if the grid bias voltage be made zero. This permits of such limitation of grid current and of zero anode current, as to produce the symmetrical limitations for the positive and negative half waves of signal to operate for input signals in excess of v . From this it follows that for the circuits above and below described, the product of I_a and R_2 (where R_2 is the value of resistance R2) should be substantially equal to v , the input signal level above which it is desired that limitation of the amplitude of the output signal shall occur.

In a preferred circuit arrangement according to the invention, illustrated in Figure 2, the valve A1 is preceded by an amplifier stage comprising a further valve A2. The latter has at least an anode, control grid, and cathode, and is connected between the positive and negative terminals of the source of anode current. A fifth resistance R5 is connected between the positive terminal of the current source and the anode of the valve A2, and a sixth resistance R6 is connected between the cathode of valve A2 and the negative terminal of the current source. A feedback circuit, including a blocking condenser CB1 and a resistance R7, extends from the anode of valve A1 to the cathode of valve A2. The anode of valve A2 is coupled, through a blocking condenser CB2, to the junction point of the resistances R3 and R4. The input signal is applied to valve A2 across a resistance R in the grid to cathode cir-

cuit thereof. With this arrangement, the amplifier stage permits of the application of a higher degree of feedback with a corresponding increase in sharpness of incidence of limitation for a lower level of input voltage v to the valve A2. The additional feedback is controlled by suitably proportioning the values of resistances R6 and R7. It, also, permits of such limiting action that less than 1% distortion of the output signal can be obtained for all signal levels less than 10% below that at which severe limitation has set in. This represents a considerable improvement over known existing limiter circuits.

Suitable values for the various components in a set-up using a "Marconi" valve designated in Great Britain as type H63 for valve A2, and a "Marconi" valve designated as type KT63 for valve A1, are as below:

	Resistive value in ohms
20 R1 -----	5,000
R2 -----	Approximately-- 1,110
R3 -----	100,000
R4 -----	500,000
R5 -----	250,000
25 R6 -----	3,000
R7 -----	Not less than-- 100,000

Various minor modifications are possible. Impedances other than resistances may be used in some positions. A variable resistance R8 may be inserted in the feed connection between the source of anode current and the reservoir or decoupling condenser C. This is illustrated, for example, in Fig. 1. In this manner a useful auxiliary control is obtained over the input voltage which produces limitation.

What I claim is:

1. A thermionic valve circuit arrangement including in combination, a thermionic valve having at least an anode, control grid and cathode, a source of anode current, a first impedance connected between the positive terminal of said current source and anode, a second unbypassed resistive impedance connected between the cathode and current source negative terminal whereby anode current flow therethrough provides a voltage which is degeneratively applied to said grid, series-connected third and fourth impedances connected between the control grid of the valve and said negative terminal, connections for applying an input signal across the fourth impedance between the junction point of said third and fourth impedances and said negative terminal, connections whereby an output signal may be taken from across the series-connected anode to cathode space of the valve and the second impedance, the values of the first and second impedances being so chosen that for an input signal of given voltage, grid current just does not flow and the valve operates at the lower bend of its anode current-grid voltage characteristic, but for an input signal of voltage higher than said given voltage, grid current flows in said second, third, and fourth impedances in such direction as to increase the effective negative bias of the control grid due to said flow of anode current in the second impedance, and the values of the third and fourth impedances being so chosen that the grid current causes a very sharp discontinuity in the change in anode current, an amplifier stage preceding said valve, said amplifier stage comprising a second valve having at least an anode, control grid, and cathode connected between the positive and negative terminals of said source of anode current, a fifth impedance between the positive

terminal of the source and the anode of the second valve, a sixth impedance connected between the cathode of the second valve and the negative terminal of the current source, a signal source coupled to said control grid of the second valve, said input signal connections of the first valve being made to said fifth impedance, a degenerative feedback circuit, including a blocking condenser and a seventh impedance, extending from the anode of the first valve to the cathode of the second valve.

2. In an amplitude limiter, a tube having at least a cathode, output electrode and control grid, a signal input circuit, an amplifier network coupling said input circuit to said grid and cathode, a signal output circuit coupled to said output electrode and cathode, an unbypassed resistor in the space current path of the tube common to the grid circuit and output electrode circuit, said resistor developing thereacross signal voltage applied as negative feedback voltage to said grid,

at least one resistor in circuit with said grid and unbypassed resistor to provide a voltage from grid current thereby to increase the effective negative bias of said grid over and above that due to said feedback, and means in circuit with said output electrode to provide a relatively low positive potential, said amplifier network including a second tube having at least a cathode, control grid and output electrode, said signal input circuit being coupled to the grid and cathode of the second tube, an unbypassed resistor in the second tube space current path, means coupling the second tube output electrode to the grid of the first tube, said last resistor being common to the grid circuit and output circuit of the second tube whereby voltage developed across the resistor is applied in degenerative phase to the grid of the second tube, and an auxiliary negative feedback path from the output electrode of the second tube to the cathode of the first tube.

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