Aug. 13, 1935. L. H. PADDLE 2,011,499

MODULATION CONTROL SYSTEM

Filed June 26, 1933 4 Sheets-Sheet 1

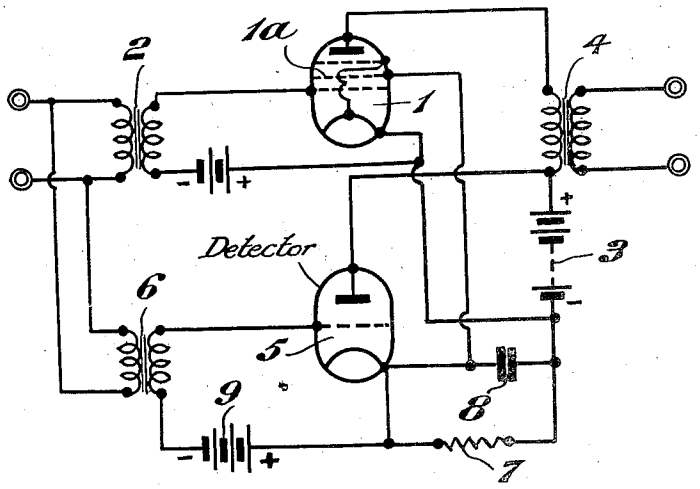


Fig. 1.

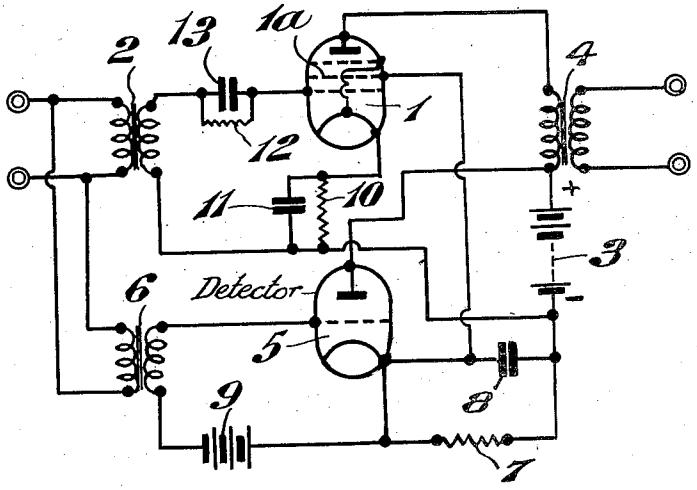


Fig. 2.

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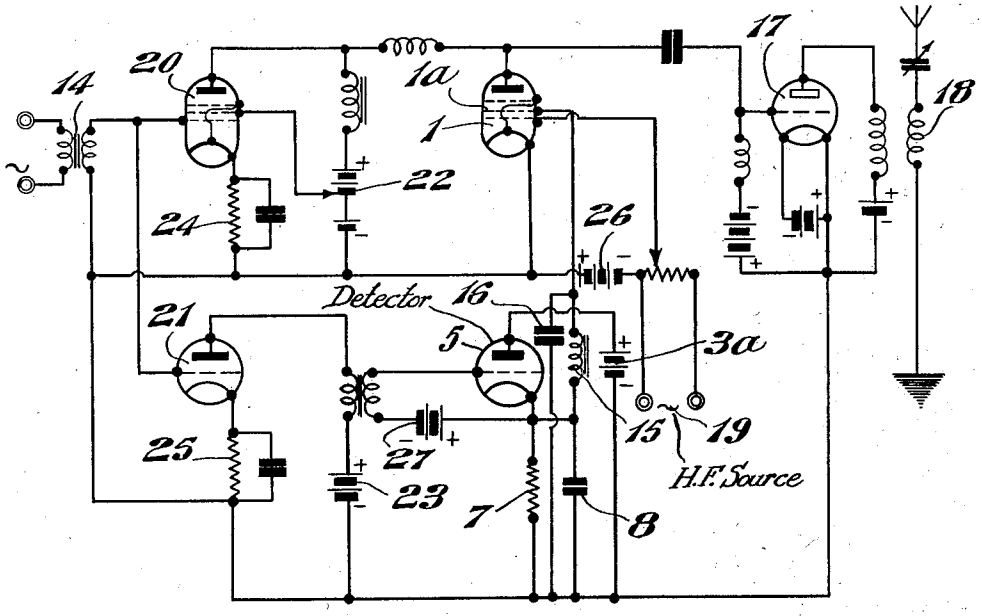


Fig. 3.

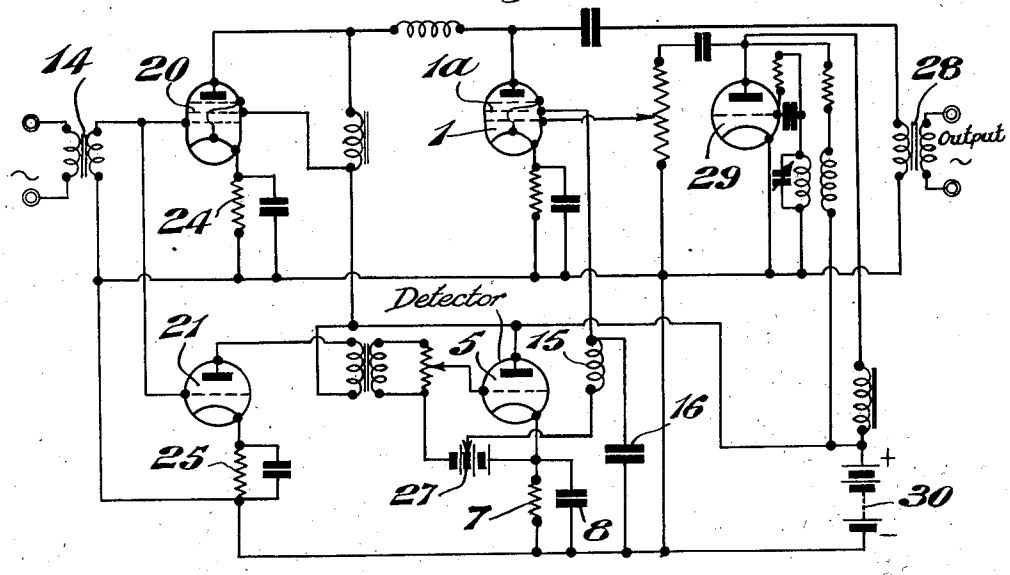


Fig. 4.

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MODULATION CONTROL SYSTEM

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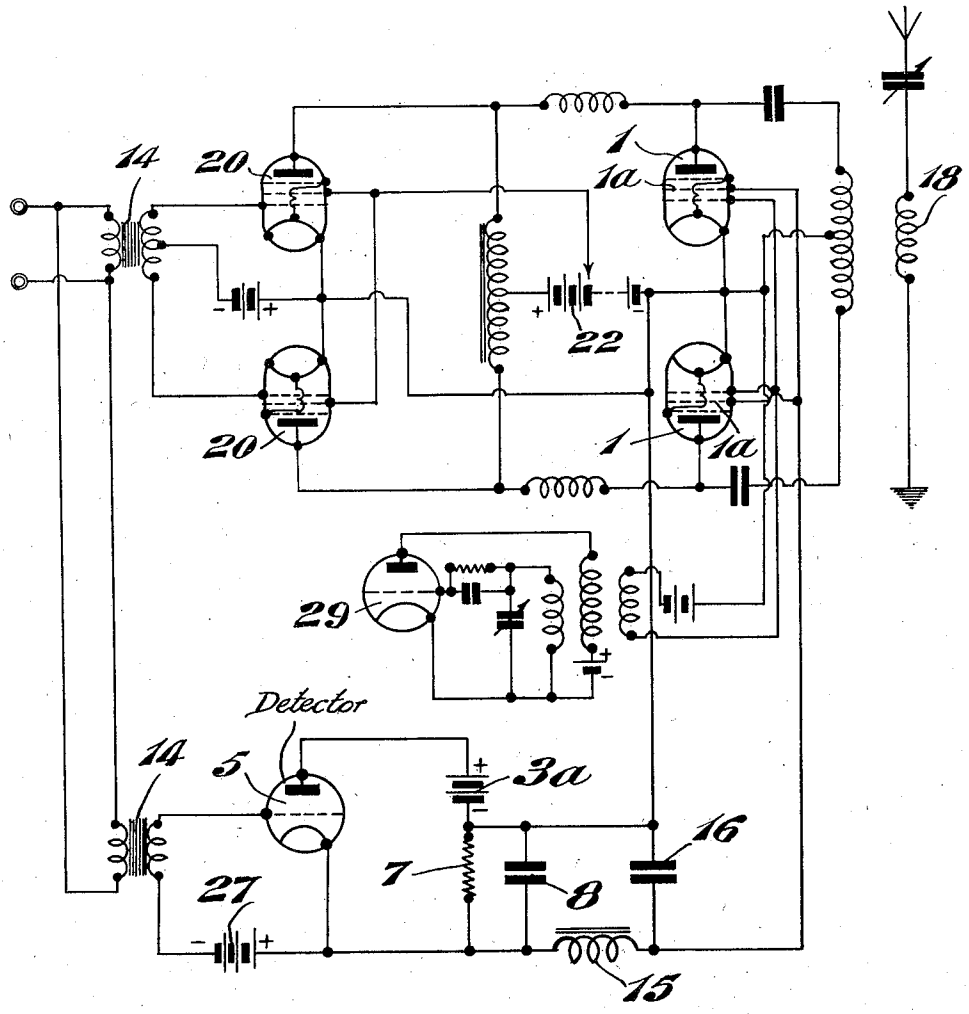


Fig. 5.

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MODULATION CONTROL SYSTEM

Filed June 26, 1933 4 Sheets-Sheet 4

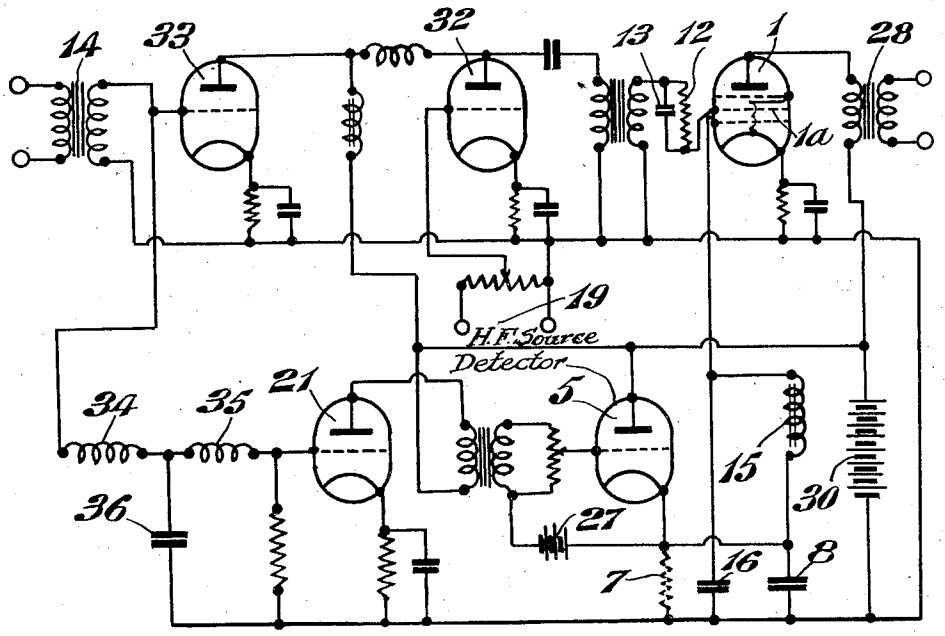
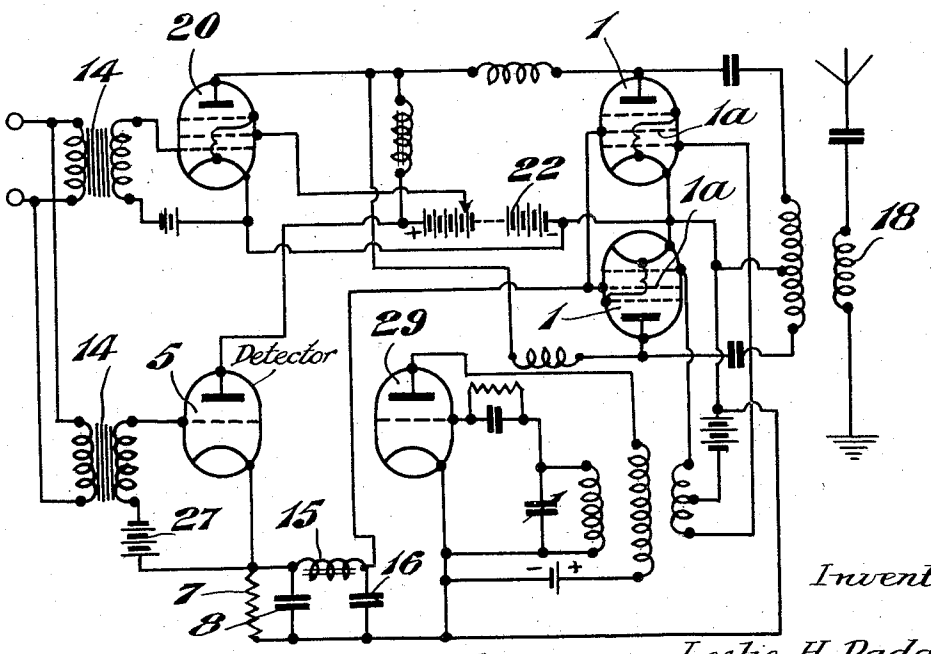


Fig.6.



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UNITED STATES PATENT OFFICE

2,011,499

MODULATION CONTROL SYSTEM

Leslie Harold Paddle, Chiswick, London, England

Application June 26, 1933, Serial No. 677,757
In Great Britain June 29, 1932

7 Claims. (Cl. 179—171)

This invention relates to the control of five-electrode thermionic valves or pentodes, that is valves having, in addition to the anode, cathode and control grid, a grid near the anode, connected to a point of low potential on the cathode to prevent secondary emission from the anode, and an auxiliary grid between the other two grids, adapted to be connected to a source of positive potential.

I have found that variations in the potential applied to the auxiliary grid, without substantially changing the anode-cathode impedance, effect corresponding variations in the static characteristic curve of the valve in such a way that reduction of said potential effects a reduction of the amount of the grid swing which the valve is capable of relaying until a point is reached at which said valve is rendered completely non-transmissive, whereas increase of said potential effects an increase of said amount until it attains a maximum when the potential of the auxiliary grid is equal to that of the anode.

The object of the invention is the provision of an improved method of controlling the output from such valves, by which method it will be possible inter-alia for either a transmitter or a receiver to be made quiescent, that is to say, adapted automatically to transmit or receive the carrier waves only when a signal is in existence to be transmitted or received.

The invention consists broadly in the arrangement that the output from the valve is controlled through variation in the potential applied to the auxiliary grid, such variation being effected automatically by some desired signal.

This potential variation may be effected automatically in response to the signal by which the carrier wave is to be modulated (when the pentode is employed in a transmitter) or by the detected audio frequency signal (when said pentode is employed in a receiver) in such a way that when there is no signal the auxiliary grid potential is reduced to the point at which the valve is non-transmitting, and when there is a signal said auxiliary grid potential is increased in proportion to the amplitude of said signal in such a way that the amount of grid swing which the valve is capable of transmitting is always sufficient to comprise the range through which the carrier wave is modulated.

In the case both of the transmitter and the receiver this potential variation may be effected through the medium of an anode bend detector operated by the signal.

In order that the invention may be the more clearly understood a number of circuits in accordance therewith will now be described reference being made to the accompanying drawings wherein:—

Figure 1 illustrates a circuit in which the pentode is employed as an amplifier in a radio receiving set.

Figure 2 illustrates a slightly different circuit to that of Figure 1.

Figure 3 illustrates a circuit in which the pentode is employed as the modulator in a transmitter.

Figure 4 illustrates a slightly different circuit to that of Figure 3.

Figure 5 is a circuit in which two pentodes are employed in push-pull as modulators in a transmitter.

Figure 6 illustrates a circuit in which the pentode is employed as the output valve of a transmitter.

Figure 7 illustrates a modification of the circuit shown in Figure 5.

Referring to Figure 1 the pentode 1 has its control grid circuit fed from the secondary of a transformer 2 whose primary is fed from the detector valve of the receiver (not shown). The plate circuit of said pentode 1 is supplied from a high tension battery 3 and includes the primary of a transformer 4 whose secondary supplies the load or output circuit.

The control of the auxiliary grid 1*a* is effected by means of an anode bend detector 5 whose grid circuit is fed from the secondary of a transformer 6 the primary of which is supplied from the said detector valve of the receiver. The plate circuit of said anode bend detector 5 is also supplied from the same high tension battery 3 which supplies the plate circuit of the pentode 1 but does not include the primary of the output transformer 4. The plate circuit of the anode bend detector 5 moreover includes a resistance 7 which is not in the plate circuit of the pentode 1, said resistance being connected between the high tension negative and the filament of said anode bend detector. Said auxiliary grid 1*a* of the pentode is connected to the filament of the anode-bend detector 5 and a fixed condenser 8 is connected between said filament and the remote side of the resistance. The grid of the anode bend detector 5 is biased by means of grid bias battery 9 so that when no speech current is applied to said grid no anode current flows in the plate circuit. Therefore no current will flow through the resistance 7 and the potential applied to the auxiliary grid 1*a* of the pentode 1

will be equal to the potential of the high tension negative. Hence the pentode 1 will be non-transmissive and the output circuit therefrom will be dead. An incoming signal however affects the grid of the anode bend detector 5, causing current to flow in the plate circuit of the latter and therefore through the resistance 7. A potential drop is therefore set up across this resistance 7 causing its end remote from the high tension negative to acquire a positive potential. This positive potential is applied to the auxiliary grid 1a of the pentode 1 and the same now becomes transmissive, amplifies the signals and passes them freely to the output.

It has been found that in some cases the resistance 7 can be omitted without impairing the control of the pentode 1 exercised by the anode bend detector 5.

Referring now to Figure 2 this shows an arrangement similar to Figure 1 in which the grid bias to the control grid of the pentode 1 is supplied by the so-called automatic method by including a resistance 10 shunted by a condenser 11, in both the grid circuit and the plate circuit, between the filament of said pentode 1 and the point of junction of the high tension negative and the secondary of the transformer. In Figure 2 moreover a resistance 12 shunted by a condenser 13 has been connected between the control grid of the pentode 1 and the secondary of the transformer 2. This has the effect of rendering the pentode 1 absolutely non-transmissive during the non-signal periods even though the anode bend detector 5 transmits a small anode current during these no-signal periods due to the difficulty of biasing it back to complete zero anode currents. The operation appears to be that, assuming during a no-signal period, a small potential to be applied to the auxiliary grid 1a of the pentode 1 due to the fact that the detector 5 is not completely non-conducting, a small current will tend to flow in the plate circuit of the pentode, and, as the control grid of the pentode is being continuously energized by the input current, there will be a tendency for rectification to take place and this will cause grid current to tend to flow. But upon the first appearance of such grid current the control grid will take up a negative potential with respect to the filament due to the potential drop in the resistance 10, and this will completely suppress the anode current rendering the valve absolutely non-transmissive.

The purpose of the condenser 13 is that of reducing to a low value the impedance to the input signals during the period of transmission, and thereby maintaining efficiency during said period of transmission.

Referring now to Figure 3 the pentode 1 is employed as a modulator in a transmitter. In this case the auxiliary grid 1a is controlled by means of an anode bend detector 5 supplied in parallel from the same low frequency input transformer 14 as the pentode 1. The control in this case is effected in the same way as in the preceding arrangements except that a low pass filter is connected in the line from the auxiliary grid 1a of the pentode 1 to the filament of the anode bend detector 5. This is to prevent the voltage applied to the control grid of the pentode 1 varying instantaneously with the rectified currents of the anode bend detector 5. It will be appreciated that this filter which may consist of a choke 15 and condenser 16, will produce a certain time lag in the operation of the auxiliary grid 1a of the pentode, but, by suitably choosing the values, a time constant of 1/50 to 1/200 of a second can be attained, which is a negligible quantity especially when speech is being transmitted.

The output from the pentode 1 is connected to the input of a large output valve 17 which is connected to the aerial circuit 18 in the usual way.

The carrier wave frequency is supplied to the control grid circuit of the pentode 1 from a source 19. Normally no carrier wave is transmitted, but as soon as the signals to be transmitted are fed into the primary of the transformer 14 fully modulated output radio signals are transmitted.

In the particular arrangement shown in the drawings the low frequency or modulating signals are supplied to the pentode 1, from the secondary of said transformer 14, through an amplifier valve 20 which is shown as being a pentode but might equally be a triode. In like manner these signals are supplied to the anode bend detector 5 through an amplifier 21. The reference 3a designates the high tension battery which is now connected to the anode bend detector only. The references 22 and 23 designate plate circuit batteries for the valves 20 and 21 respectively. The valves 20 and 21 are provided with automatic grid biasing resistances 24 and 25, whereas grid bias to the valves 1 and 5 is provided by grid biasing batteries 26 and 27. Other details are deemed clear from the drawings.

The arrangement of Figure 4, which is highly suitable for small transmitters, differs from that of Figure 3 in a number of respects. Firstly the output valve 17 is dispensed with and the pentode 1 employed as output valve as well as modulator, the primary of an output transformer 28 being connected in the output circuit of sand pentode 1. Also an oscillator valve 29 is provided for driving said pentode 1.

Further instead of the choke 15 of the low pass filter being connected, at its end remote from the auxiliary grid 1a, to the filament of the anode bend detector 5, it is connected to a tapped point of the grid bias battery 27 which is negative with respect to said filament. The connection of the choke 15 to a point negative with respect to the filament may be necessary in certain cases, as I have found, as heretofore stated, that it is very difficult to bias back the anode bend detector valve 5 to zero anode current during the no-signal periods unless a very large battery is employed. I therefore sometimes find it more convenient to allow a small current to flow in the anode circuit of the valve 5 during the no-signal periods, corresponding with the bend in the characteristic of said valve, as this is the most sensitive point of its characteristic. A small current therefore passes through the resistance 7 in the anode circuit of said anode bend detector 5 and due to this current a small voltage would normally be applied to the auxiliary grid 1a of the pentode 1, but by connecting the choke 15 to a point which is negative with respect to the filament of the valve 5, that is with respect to the end of the resistance 7 remote from the high tension, this may be compensated for so that, as before, no potential is applied to the auxiliary grid 1a of the pentode 1 when no signals are present.

Figure 4 also differs from Figure 3 in that, instead of the several high tension batteries 3a, 22, 23, a common high tension battery 30 is employed for the valves 5, 20 and 21. Other details such as the substitution of a resistance 31 for the grid

bias battery 26 are deemed clear from the drawings.

Figure 5 illustrates an arrangement similar to Figures 3 and 4 but in which two pentode valves 1 have their anodes connected in push-pull. In this arrangement it will be seen that the amplifying valve 21 of Figures 3 and 4 has been dispensed with and that the oscillator valve 29 is transformer coupled instead of resistance coupled to the pentodes 1. Otherwise, except that as stated the pentodes 1 and amplifiers 20 are in push-pull, the circuit of Fig. 5 is similar to those of Figures 3 and 4 and it is deemed that the operation will be clear from the drawings in view of the fact that like references are employed for corresponding parts in this Figure 5 as are employed in Figures 3 and 4.

It may be remarked that, in this arrangement, since the control grids of the pentode 1 are connected in parallel, if said pentodes were completely balanced there would be no carrier output when there was no modulating input signal, even if the auxiliary grid control in accordance with the present invention were not employed. However, in practice it is usually impossible to obtain valves which are completely balanced and a certain amount of carrier output would be normally transmitted if the auxiliary grid control were not employed.

Referring now to Figure 6 this shows a transmitter in which the pentode valve 1 is employed as an output valve and is fed from a triode high frequency amplifier valve 32 which acts as modulator. The valve 32 is fed with the low frequency modulating current from the transformer 14 through the medium of a triode valve 33 as shown which takes the place of the pentode 20 of Figure 4, and is fed with unmodulated high frequency current from the source 19 as shown. The control of the auxiliary grid 1a is effected by means of the anode bend detector 5 in the same way as in Figure 3, a resistance 12 shunted by a condenser 13 being employed as in Figure 2 in order that complete quiescence shall be achieved during the no-signal periods. The anode bend detector is fed, from the transformer 14 through the amplifier 21 as in Figure 4, and this valve 21 has connected in the input circuit thereof a low pass filter consisting of inductances 34 and 35 and a condenser 36. This prevents any high frequency currents which may be fed back through the inter-electrode capacity of the valve 33 from being amplified by the valve 21 and fed to the valve 5. It will be appreciated that, if high frequency currents are fed to the valve 5, anode current will not be entirely suppressed during the no-signal period and therefore the pentode will not be entirely quiescent.

Figure 7 shows a similar arrangement to that of Figure 5, the two pentodes 1 being connected in push-pull. This arrangement differs from that of Figure 5 primarily in that the two valves 1 are fed from a single valve 20 instead of two valves 20 also connected in push-pull. A further minor difference is that the separate battery 3a for the plate circuit of the anode bend detector 5 is dispensed with, the battery 22 being employed for this purpose.

It will be clear to those skilled in the art that the invention is applicable to carrier wave telephony as well as radio.

It will also be clear that a low pass filter could be employed in the case when the pentode is used as the output valve of a receiver, as well as, as hereinbefore described, in the case when the pentode is used as a modulator or output valve of a transmitter.

What I claim and desire to secure by Letters Patent is:

1. In a modulating system, a modulator tube having cathode, anode, control grid, and auxiliary grid, an input circuit connected between said control grid and said cathode of said modulator tube, a rectifier tube having cathode, anode and grid and having its input circuit in electric relation with the input circuit of said modulator tube, an output circuit for said rectifier tube comprising a resistor, an output circuit for said modulator tube, said output circuits having a common portion comprising a source of anode potential, and connections between the cathode and auxiliary grid of said modulator tube and said resistor and said source of anode potential such that said source of anode potential applies to said auxiliary grid a negative potential with reference to the cathode of said modulator tube, and the voltage drop in said resistor due to output current of said rectifier tube applies to said auxiliary grid a positive potential with reference to the cathode of said modulator tube.

2. In a modulating system, a modulator tube having cathode, anode, control grid, and auxiliary grid, an input circuit connected between said control grid and said cathode of said modulator tube, a rectifier tube having cathode, anode and grid and having it input circuit in electric relation with the input circuit of said modulator tube, a common source of anode potential for said tubes, having its negative terminal connected to the cathode of said modulator tube, and a resistor connected between the negative terminal of said source and the cathode of said rectifier tube, said auxiliary grid of said modulator tube being connected to the cathode of said rectifier tube.

3. In a modulating system, a modulator tube having cathode, anode, control grid, and auxiliary grid, an input circuit connected between said control grid and said cathode of said modulator tube, a rectifier tube having cathode, anode and grid and having its input circuit in electric relation with the input circuit of said modulator tube, an output circuit for said rectifier tube comprising a resistor, an output circuit for said modulator tube, said output circuits having a common portion comprising a source of anode potential, connections between the cathode and auxiliary grid of said modulator tube and said resistor and said source of anode potential such that said source of anode potential applies to said auxiliary grid a negative potential with reference to the cathode of said modulator tube, and the voltage drop in said resistor due to output current of said rectifier tube applies to said auxiliary grid a positive potential with reference to the cathode of said modulator tube, and means for applying negative bias potential to the grid of said rectifier tube with reference to its cathode for substantially preventing the delivery of any output current therefrom when no input energy is applied to the input circuit of said rectifier tube.

4. In a modulating system, a modulator tube having cathode, anode, control grid and auxiliary grid, a modulator resistor having one terminal connected to the cathode of said modulator tube, an input circuit for said modulator tube connected between the terminal of said resistor remote from said cathode and said control grid, a rectifier tube having cathode, anode, and grid,

and having its input circuit in electrical relation with the input circuit of said modulator tube, a common source of anode potential for said tubes having its negative terminal connected to said terminal of said modulator resistor remote from said cathode, and a rectifier resistor connected between the negative terminal of said source and the cathode of said rectifier tube, said auxiliary grid of said modulator tube being connected to the cathode of said rectifier tube.

5. In a modulating system, a modulator tube having cathode, anode, control grid, and auxiliary grid, an input circuit connected between said control grid and said cathode of said modulator tube, a rectifier tube of the anode-bend type having cathode, anode and grid and having its input circuit in electric relation with the input circuit of said modulator tube, an output circuit for said rectifier tube comprising a resistor, an output circuit for said modulator tube, said output circuits having a common portion comprising a source of anode potential, connections between the cathode and auxiliary grid of said modulator tube and said resistor and said source of anode potential such that said source of anode potential applies to said auxiliary grid a negative potential with reference to the cathode of said modulator tube, and the voltage drop in said resistor due to output current of said rectifier tube applies to said auxiliary grid a positive potential with reference to the cathode of said modulator tube, and means for applying negative bias potential to the grid of said rectifier tube with reference to its cathode in such manner that said rectifier tube operates on its anode bend and substantially no output current is delivered therefrom when no input energy is applied to the input circuit of said rectifier tube.

6. In a modulating system, a modulator tube having cathode, anode, control grid, and auxiliary grid, an input circuit connected between said control grid and said cathode of said modulator tube, a rectifier unit having its input circuit in electrical relation with the input circuit of said modulator tube, means for applying to the auxiliary grid of said modulator tube a fixed negative potential with reference to its cathode, an output circuit for said rectifier unit comprising a resistor, and a circuit comprising a low-pass filter having a time constant of the order of 1/50th to 1/200th of a second connecting the terminals of said resistor respectively to said cathode and said auxiliary grid of said modulator tube in such manner that the potential drop due to rectifier output current opposes the potential applied to said auxiliary grid by said means, whereby the operation of said modulator tube is controlled through the portion of its input energy derived and applied through said rectifier unit.

7. In a modulating system, a modulator tube having cathode, anode, control grid, and auxiliary grid, a source of sound-frequency current connected to the input circuit of said modulator tube, a rectifier tube having cathode, anode, and grid, and having its input circuit in electrical relation with the input circuit of said modulator tube, an output circuit for said rectifier tube comprising a resistor, an output circuit for said modulator tube, said output circuits having a common portion comprising a source of anode potential, a source of rectifier grid bias potential provided with an intermediate tap connected for applying negative bias potential to the grid of said rectifier tube with reference to its cathode, and a circuit comprising a low-pass filter delivering the potential between the negative terminal of said source of anode potential and said intermediate tap across the cathode and auxiliary grid of said modulator tube.

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