April 7, 1942. J. D. REID 2,279,058

DETECTOR FOR FREQUENCY MODULATION SIGNALS

Filed Oct. 26, 1940

Fig. 1.

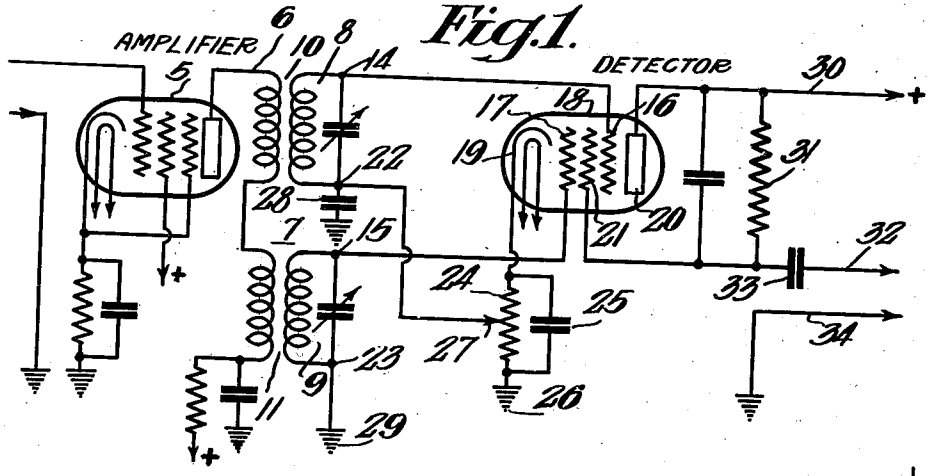


Fig. 2.

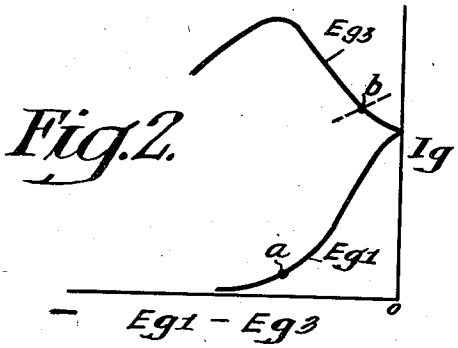


Fig. 4.

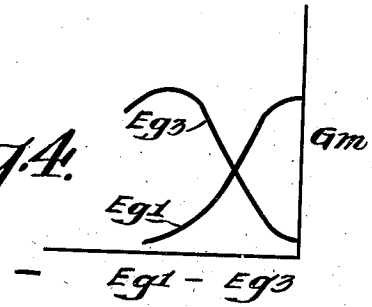
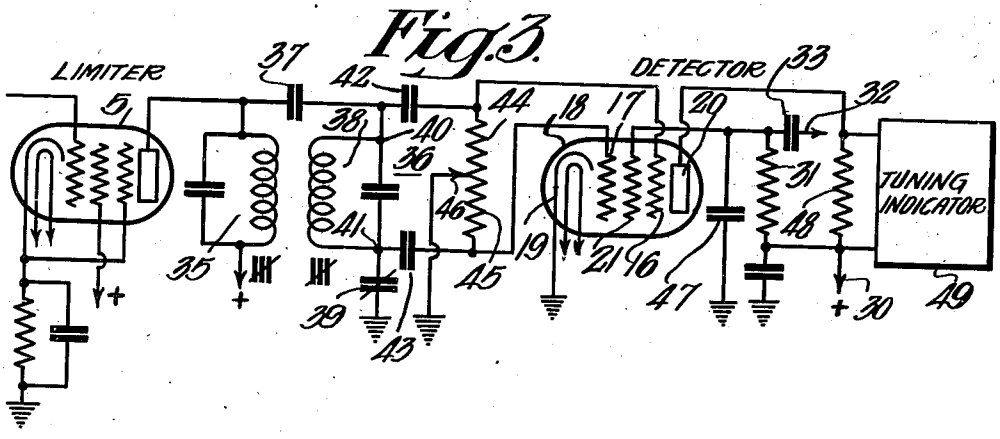


Fig. 3.



Inventor
John D. Reid

By J. Zuff
Attorney

Patented Apr. 7, 1942

2,279,058

UNITED STATES PATENT OFFICE

2,279,058

DETECTOR FOR FREQUENCY MODULATION SIGNALS

John D. Reid, Philadelphia, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Application October 26, 1940, Serial No. 362,911

6 Claims. (Cl. 250—27)

This invention relates to detectors for frequency-modulated signals, and has for an object to provide a balanced detector having an increased sensitivity, and a decreased loading for an input signal circuit, over the conventional diode rectifier arrangement at present provided in detectors of this type.

The signal gain from the last I.-F. amplifier stage to the grid of the first audio frequency amplifier stage is relatively low in frequency-modulated signal receiving systems embodying the usual discriminator network provided with diode rectifiers.

It is, therefore, an object of this invention to provide a detector for frequency-modulated signals which provides a higher degree of sensitivity or gain from the input to the output circuits thereof, and which provides a relatively high gain while retaining a balanced operating condition which substantially cancels amplitude-modulated signals.

It is also a further object of this invention to provide a frequency-modulated signal detector which is substantially the equivalent of a grid leak or plate detector in an amplitude-modulated signal receiving system, whereby the same high degree of sensitivity and gain may be provided in a frequency modulation signal receiving system.

It is a further object of this invention to provide a frequency modulation detector system wherein a single detector device of the electronic discharge type is provided with a cathode, a main anode, and, in addition, with an auxiliary anode or signal output electrode and two signal input electrodes, the mutual conductance characteristics of which input electrodes with respect to the said output electrode provide opposite and equal slope with predetermined biasing potential.

It is a still further object of the present invention to provide an improved frequency modulation detector system comprising a frequency discriminator network and a detector tube having a cathode, an anode, and first, second and third electrodes in the order named between the cathode and anode, the first and third electrodes being essentially control grids connected with the output terminals of the discriminator network whereby the latter is substantially unloaded, and the second electrode being essentially an output electrode or auxiliary anode, the mutual conductance characteristics of which with respect to the first and third electrodes provide substantially equal and opposite slopes with predetermined bias potential, for frequency modulation detection with a high degree of sensitivity and selectivity.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawing, and its scope is pointed out in the appended claims.

In the drawing,

Figure 1 is a schematic circuit diagram of a frequency modulation detector system embodying the invention,

Figure 2 is a graph showing curves illustrating certain operating characteristics of the circuit of Figure 1,

Figure 3 is a schematic circuit diagram of a frequency modulation detector system also embodying the invention and showing a modification of the input and output circuits, and

Figure 4 is a graph showing curves illustrating certain operating characteristics of the circuits of Figures 1 and 3.

Referring to Fig. 1, 5 may be taken to represent the output or limiter stage of an intermediate frequency amplifier coupled through an output circuit 6 to a frequency discriminator network 7 of any suitable type. In the present example, this comprises a circuit 8 tuned above, and a circuit 9 tuned below, the center frequency, both circuits being coupled to the output circuit 6 of the amplifier stage 5 through suitable coupling transformers 10 and 11, the secondaries of which are in the tuned circuits 8 and 9 and the primaries of which are in the circuit 6 as indicated.

The tuned circuits 8 and 9 provide output potentials which are equal at the center frequency. The output terminals 14 and 15 of the network are connected to a pair of control grids 16 and 17 in a detector tube 18 having a cathode and a main output anode 20. In addition, the tube is provided with a third electrode 21 between the cathode and anode which may be termed an auxiliary anode. The tube, therefore, may be of the pentode type in which the first, second and third electrodes 17, 21 and 16 in the order named may be located between the cathode and the anode.

The low potential terminals 22 and 23 of the circuits 8 and 9, respectively, are connected to a suitable source of biasing potential 24 interposed in circuit with the cathode 19 and comprising in the present example a self-biasing resistor provided with a by-pass capacitor 25, the

resistor being connected preferably to ground, as indicated at 26.

The terminal 22 is connected to an adjustable tap connection 27 on the resistor 24 and is provided with a by-pass capacitor 28 to ground, while the terminal 23 is connected to the ground end of the resistor 24, as indicated by the ground connection 29. With this arrangement, the bias potential from the source 24 on the grids 16 and 17 may be adjusted one with respect to the other for reasons which will hereinafter appear.

The main anode 20 is connected to a source of positive anode potential indicated by the supply lead 30, the chassis or ground being the negative side thereof, and the auxiliary anode of the electrode 21 is likewise connected to the positive source through an output impedance or resistor 31 to the anode end of which is coupled an output circuit indicated at 32, through an output coupling capacitor 33. The output circuit is completed through a return lead indicated at 34, connected to ground or chassis.

With this arrangement, signals applied to the receiving system through the amplifier stage 5 are applied in turn to the discriminator network 7 and to the control electrodes 16—17 of the detector 18, causing a signal to be established in the output circuit from the auxiliary anode 21.

The system operates to detect and convert frequency-modulated signals into audio frequency signals by the action of the two control grids 16 and 17 in connection with the discriminator network 7, and the mutual conductance relation between the electrodes 16, 17 and 21, which may be understood with reference to Fig. 2, wherein the curve Eg3 is the anode current flow to the electrode 21, as the bias potential on Eg3 or grid 16 is varied between predetermined limits, in the present example, in a negative direction from zero. Likewise, the curve Eg1 represents the current to the electrode 21 as the bias potential Eg1 is varied on the control grid 17, and, in the present example, in a negative direction from zero.

It will be noted that, at a certain biasing potential, as at point *a* on the curve Eg1, the slope of the curve is equal and opposite to the slope of the curve Eg3 at the point *b*. Thus, by adjusting the biasing potential on the two control electrodes 16 and 17, one with respect to the other, the anode current to the electrode 21 will operate about the points *a* and *b* with plate rectification, resulting in a decreased load on the discriminator circuits and increased sensitivity as compared with diode detectors ordinarily provided.

The effect of the circuit arrangement is to provide the second grid or electrode 21 with equal and opposite slope on mutual conductance with respect to the first and third grids 17 and 16. Stated in other words, the first grid 17 has positive mutual conductance with respect to the second electrode or grid 21, while the third grid 16 has a negative mutual conductance with respect to the grid of the electrode 21.

The effect of the mutual conductance is shown in Fig. 4 in which the mutual conductance curves with respect to the electrode 21 are shown for the first and third grids 17 and 16, respectively, at Eg1 and Eg3. The bias potentials are so chosen on the control grids 17 and 16 that slopes are equal and opposite, although the bias potential on each grid may be different from that on the other. Thus, the system is sensitive to frequency modulation signals and does not respond to amplitude-modulated signals.

The modification of the circuit of Fig. 1 wherein the detector 18 is operated as a grid leak detector rather than with plate rectification, as in Fig. 1, is shown in Fig. 3, to which attention is now directed.

In Fig. 3, the amplifier stage 5 may be a limiter as well, and is provided with a tuned output circuit 35, across which is coupled a discriminator network 36 through a coupling capacitor 37. The discriminator comprises a tuned circuit 38 connected with a series-resonating capacitor 39 and the output is taken from terminals 40 and 41 to the control grids 16 and 17 of the detector 18. The grid coupling capacitors for the grids 16 and 17 are indicated at 42 and 43, respectively, and the grid leak connection to cathode is provided by grid leak resistors 44 and 45 to ground to which the cathode 9 is also connected.

The grid leak operation of the circuit is in accordance with the curve shown in Fig. 4, the grid resistors being adjusted by a contact 46 to suitable relative values for providing bias effective to cause the negative mutual conductance characteristic for the two control electrodes with respect to the auxiliary electrode 21 to have opposite and equal slopes.

This system, however, will operate only over a limited range of input signal and, therefore, should preferably be preceded by a limiter stage, as indicated. Also, while this arrangement provides a greater sensitivity than the circuit of Fig. 1, it provides a greater load on the discriminator circuit. As in the preceding figure, the discriminator operates to provide output potentials at the terminals 40 and 41 which are equal at the center frequency.

The output audio frequency signal is derived across the output resistor 31 connected with the electrode 21, through the coupling capacitor 33 and the output circuit 32. Suitable bypass capacitors 47 may be provided for the output circuit.

A series resistor or output impedance may be provided in circuit with the main anode 20, as indicated at 48, to provide a voltage change in response to signals for operation of a tuning indicator 49 or other suitable apparatus for which operation is desired without affecting the main output circuit or the signal channel through the circuit 32. Thus, with the systems shown, tuning indication may be provided in connection with one of the anode electrodes, such as the main anode, while audio frequency output signals are derived from the auxiliary anode, or second grid, in the present example, in the case of a pentode tube, this grid being in a position normally occupied by the screen grid.

The use of an amplifier tube as a frequency modulation detector in connection with a frequency discriminator network has the advantage that the signals are amplified, making the detector circuit more sensitive than the usual diode circuit, and without loading the signal input circuits thereto.

Furthermore, by providing a positive and negative mutual conductance characteristic to an output electrode interposed between two signal input electrodes operating as control grids, and with biasing potentials on said grids so chosen that the slope of the mutual conductance characteristics of the output electrode are equal and opposite with respect to the control grids, effective frequency modulation detection is provided while maintaining an effective balanced condi-

tion with respect to amplitude-modulated signals.

I claim as my invention:

1. A balanced detector for frequency modulated signals comprising in combination a frequency discriminator network having two output terminals, an amplifier tube having two control electrodes connected with said terminals and an output electrode interposed therebetween, said control electrodes having positive and negative mutual conductance characteristics with respect to said output electrode providing opposite and equal slope with predetermined biasing potentials on said control electrodes, an output circuit connected with said output electrode, and means connected with said control electrodes for applying said biasing potentials thereto to effect frequency modulation detection.

2. A balanced detector for frequency-modulated signals comprising, in combination, a signal amplifier stage having an output circuit, a frequency discriminator network coupled to said output circuit for receiving amplified frequency-modulated signals therefrom, said network having signal output terminals providing signal potentials which are substantially equal at a predetermined center frequency, an amplifier tube having a pair of control grids one coupled to each of said terminals and an output electrode interposed between said control grids, means connected with said control grids for adjusting the mutual conduction relation of said control grids with respect to said output electrode to effect a balance in said detector in response to amplitude-modulated signals, and an output circuit coupled to said output electrode.

3. A frequency modulation detector system comprising a frequency discriminator network, a detector tube having a cathode, an anode, and first, second and third electrodes in the order named between the cathode and the anode, said first and third electrodes being essentially control electrodes connected with the output terminals of the said discriminator network, whereby the latter is substantially unloaded, said second electrode being essentially an output electrode having mutual conductance characteristics with respect to the first and third electrodes to provide substantially equal and opposite slopes with predetermined bias potentials for effective frequency modulation detection with a high degree of sensitivity, an output circuit connected with said second electrode, and means connected with said control electrodes for applying said biasing potentials thereto.

4. The combination of a frequency discriminator network having output terminals providing balanced signal potentials at a predetermined center frequency, an amplifier tube having an anode, a cathode, and first, second and third grid electrodes interposed between said cathode and anode in the order named, means providing a connection between the terminals of said network and the first and third grid electrodes, means providing a cathode connection with said network, means for applying a predetermined biasing potential to the first and third grid electrodes with respect to the cathode, thereby to establish predetermined positive and negative mutual conductance characteristics for the first and third grid electrodes with respect to the second grid electrode as a signal output electrode, the slope of the said characteristics being equal and opposite in response to predetermined biasing potentials to provide effective frequency modulation detection without amplitude modulation response, and means for deriving an output signal from said second grid electrode comprising an output impedance element and a source of positive anode potential connected between said electrode and the cathode.

5. The combination of a frequency discriminator network having output terminals providing balanced signal potentials at a predetermined center frequency, a detector tube having an anode, a cathode, an auxiliary anode electrode, and a pair of control electrodes connected with said terminals, the auxiliary electrode having mutual conductance characteristics with respect to said control electrodes providing equal and opposite slopes in response to predetermined biasing potentials on said control electrodes, means for applying a predetermined biasing potential to each of said control electrodes, means for deriving from said detector an output potential in response to frequency-modulated signals applied to said discriminator network, said last-named means including an output impedance in circuit with said auxiliary electrode, and means for applying a positive operating potential between said cathode and said auxiliary electrode through said output impedance.

6. The combination of a frequency discriminator network having output terminals providing balanced signal potentials at a predetermined center frequency, a detector tube having an anode, a cathode, an auxiliary anode electrode, and a pair of control electrodes connected with said terminals, the auxiliary electrode having mutual conductance characteristics with respect to said control electrodes providing equal and opposite slopes in response to predetermined biasing potentials on said control electrodes, means for applying a predetermined biasing potential to each of said control electrodes, means for deriving from said detector an output potential in response to frequency-modulated signals applied to said discriminator network, said last-named means including an output impedance in circuit with said auxiliary electrode, means for applying a positive operating potential between said cathode and said auxiliary electrode through said output impedance, a second output impedance in circuit with the first-named anode electrode and cathode, and means for deriving a signal variable control potential therefrom.

JOHN B. REID.