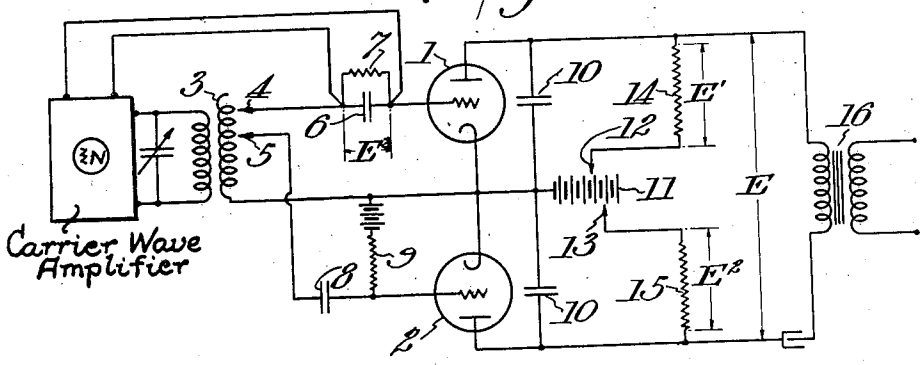
Nov. 20, 1934. K. C. BLACK 1,981,342

VACUUM TUBE DETECTOR

Filed April 21, 1930

Fig. 1.



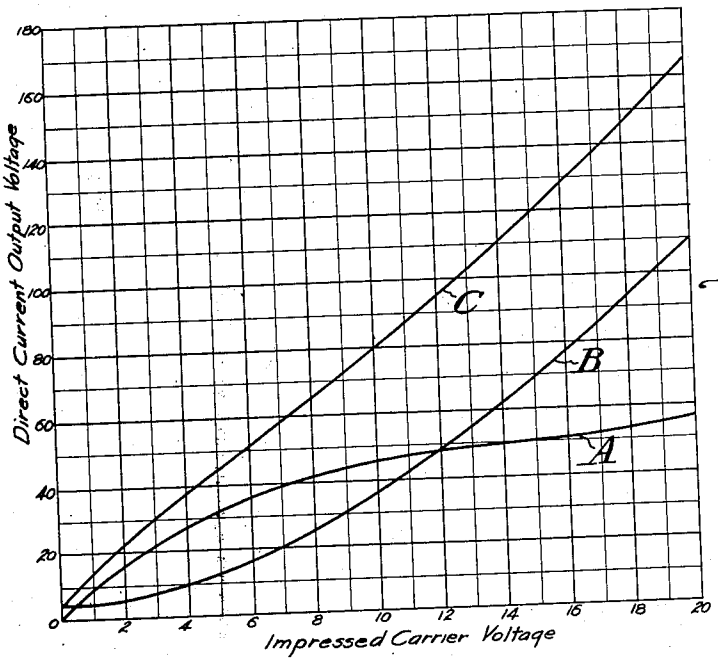


Fig. 2.

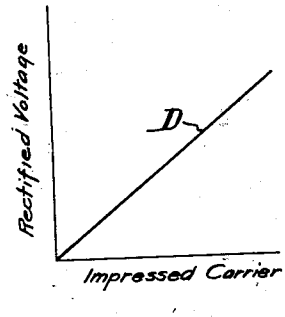


Fig. 3.

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VACUUM TUBE DETECTOR

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Application April 21, 1930, Serial No. 446,097

11 Claims. (Cl. 250—27)

This invention relates to vacuum tube detectors and more particularly to methods of and circuits for obtaining a desired and predetermined relationship between impressed signal voltage and rectified output.

In accordance with the present invention, linear rectification may be effected over a wide range of signal voltages by combining grid circuit and plate rectification in a single rectifier stage. The general arrangement of the rectifier stage may be stated as comprising two rectifier tubes having their input circuits in parallel and their output circuits in series.

Objects of the invention are to provide improved methods of and circuits for the rectification of alternating voltages, particularly modulated carrier wave signals. Further objects are to provide methods of and circuits for the demodulation of signals, which methods and circuits are characterized by high sensitivity and substantial freedom from distortion over a wide range of signal voltages. More particularly, objects are to provide methods of demodulation by which the relationship of rectified output to impressed signal voltage may be adjusted by combining, in predetermined ratio, the effects of grid and of plate rectification.

These and other objects of the invention will be apparent from the following specification, when taken with the accompanying drawing in which:

Fig. 1 is a circuit diagram of a vacuum tube rectifier stage embodying the invention, and

Figs. 2 and 3 are curve sheets showing the variation of rectified output voltage with alternating signal voltage.

As shown in Fig. 1, the signal voltage is impressed, in parallel, upon the rectifier tubes 1 and 2. The input impedance may take the form of a transformer secondary 3 which has one terminal connected to the cathodes and which preferably has some provision for receiving adjustable taps 4, 5 which lead to the grids of the respective tubes 1 and 2. The customary grid condenser 6 and leak resistance 7 are included in the input circuit of tube 1, and tube 2 is fed through the blocking condenser 8, the bias for plate rectification being applied through a resistor 9 in the usual manner. The respective plate circuits are by-passed for radio frequency currents by condensers 10, and the plate voltages are supplied from a common source 11, the voltages on the respective plates being preferably adjustable, by taps 12, 13, respectively, in order that the tubes may be individually controlled.

The audio frequency impedances across which the rectified voltages are developed are shown in Fig. 1 as resistances 14, 15, respectively, but it will be apparent that these impedances may take the form of chokes, transformers, or other output devices. The output circuit 16 of the stage may be connected across the plate terminals of the resistances 14, 15, and is shown as an audio frequency transformer although other forms of audio frequency impedance may be employed.

Since the stage output circuit 16 is connected across the serially arranged impedances 14, 15 of the individual plate circuits, it will be apparent that the stage output voltage E is equal to the sum of the voltage E^1, which is developed across impedance 14 by grid circuit rectification, and the voltage E^2 which is developed across impedance 15 by plate circuit rectification.

In Fig. 2, the curve A is the characteristic curve showing the relationship between direct current output voltage and unmodulated radio frequency input voltages for the grid circuit rectifier tube 1, and the curve B is a similar curve for the plate rectifier tube 2. The total output voltage E may be determined graphically by combining curves A and B, and the variation of the direct current potential drop E with unmodulated input voltages is shown by the curve C. The relative magnitudes of the input voltages impressed upon the separate tubes may be adjusted by the taps 4, 5 of the input circuits, or, when the input voltages are identical, the relative magnitudes of the rectified voltages arising from grid and from plate rectification may be controlled by adjustment of the taps 12, 13 which determine the plate voltages of the respective tubes. Either or both of these control methods may be employed, and, if desired, a further control may be effected by connecting the terminals of the stage output circuit 16 to the plate impedances 14, 15 through adjustable taps.

In the case of radio receiver operation, it will usually be preferable to combine the individual rectified voltages E^1 E^2 in such ratio that the curve for voltage E will take the form shown in Fig. 2, i. e., linear rectification will obtain over an extended range of applied alternating current voltages. The invention is not limited however to this particular adjustment of the operating conditions of the respective tubes, since some

other form of characteristic may be found desirable for special uses.

An examination of the curve A of Fig. 2 will show that the grid rectification of tube 1 gives a substantially linear response for a short range of small signal voltages, but that beyond a certain point, rectification occurs in the plate circuit of tube 1, and the plate-current-grid-voltage characteristic itself departs from linearity (usually both effects occur) and the output voltage no longer increases as a linear function of the applied voltage. The operation of the tube 2 is indicated by curve B which shows a longer range of linear response for plate rectification but substantially no rectification or non-linear rectification is effected at signal voltages corresponding to the range over which linear grid circuit rectification is obtainable. The curve C for the output voltage E of the complete rectifier stage shows that linear rectification may be effected at signal voltages from zero up to the maximum value corresponding to linear plate circuit rectification. By adjusting the incoming carrier voltage to bring the point of operation to the center of the linear portion of curve C, any modulation of the carrier up to one hundred per cent will be reproduced faithfully in the amplitude variation of the stage output voltage E. The rectified voltage E^3 which is developed across the grid condenser 6 is a linear function of carrier voltages falling outside of as well as those falling within the range of linear grid circuit recification. The variation of voltage E^3 with increasing carrier voltage is shown by curve D of Fig. 3, and it will be apparent that this rectified voltage may be employed, if desired, for the automatic control of the transmission through a carrier wave amplifier which will usually be associated with the detector stage.

The present invention is to be distinguished from the usual grid rectification circuits which, with increasing signal strength, produce plate rectification in opposition to the grid rectification. In accordance with the present invention, the rectified voltages resulting from plate rectification and from grid rectification are combined in additive relation, and not in opposition.

I claim:

1. In a rectifier stage, a vacuum tube and associated circuit elements constituting a grid circuit rectifier, a second vacuum tube and associated circuit elements constituting a plate circuit rectifier, a source of signal voltage, means including a pair of independent condensers connected to different potential points of said source for impressing an alternating signal voltage in parallel upon said rectifiers, and a stage output circuit connected to said rectifiers to combine in additive relation the rectified voltages developed in the respective rectifiers.

2. The invention as set forth in claim 1 in combination with means for adjusting the relative magnitudes of the rectified voltages delivered to said stage output circuit.

3. A rectifier stage comprising two vacuum tubes, circuit elements providing for said tubes input circuits which are in parallel as regards incoming signals, an output circuit for each of said tubes, means in the circuits of the individual tubes to produce grid circuit rectification in one tube and plate circuit rectification in the second tube, a stage output circuit fed from the output circuits of the individual tubes, and independently adjustable means in the output circuits of said tubes for regulating the feeding of rectified signals from each tube to said stage output circuit.

4. A rectifier stage comprising two vacuum tubes having input circuits in parallel, a pair of independently adjustable audio frequency impedances serially connected between the anodes of said tubes, a connection from the junction of said impedances to the cathodes of said tubes, means in one input circuit to cause the tube associated therewith to operate as a grid circuit rectifier, means in the other input circuit to cause the tube associated therewith to operate as a plate circuit rectifier, and a stage output circuit across which is developed at least a part of the rectified potentials established in the individual impedances.

5. In a radio receiving circuit, a source of signal modulated carrier frequency energy, a signal responsive circuit, a space discharge device in combination with circuit elements constituting a grid circuit rectifier, a second space discharge device in combination with circuit elements constituting a plate circuit rectifier, means including a pair of independent condensers connected to different potential points of said source for impressing energy from said first-named source in parallel upon said rectifiers for causing rectification thereof, in both said rectifiers, and means for combining in additive relation the rectified voltages developed in the respective rectifiers.

6. In a radio receiving circuit, a high frequency circuit, a signal responsive circuit, a space discharge device and associated circuit elements constituting a grid circuit rectifier, a second space discharge device and associated circuit elements constituting a plate circuit rectifier, both said space discharge devices and associated circuits being connected between said high frequency circuit and said signal responsive circuit, adjustable means for capacitatively connecting the grid circuit of the plate circuit rectifier device to said high frequency circuit, said signal responsive circuit being adapted to receive, combined in additive relation, the rectified voltages developed in the respective rectifiers.

7. In combination with a detector stage including a pair of tubes, a signal circuit, a load circuit, an adjustable connection to said signal circuit from the grid of one of the tubes, said connection including a network rendering said one tube a grid circuit rectifier, a second adjustable connection including a condenser between said signal circuit and the grid of the remaining tube, means associated with the said remaining tube rendering it an anode circuit rectifier, and a common output circuit coupling the anodes of said tubes to said load circuit.

8. In combination with a detector stage including a pair of tubes, a signal circuit, a load circuit, an adjustable connection to said signal circuit from the grid of one of the tubes, said connection including a network rendering said one tube a grid circuit rectifier, a second adjustable connection including a condenser between said signal circuit and the grid of the remaining tube, means associated with the said remaining tube rendering it an anode circuit rectifier, a common output circuit coupling the anodes of said tubes to said load circuit, a source of positive anode potential in said common output circuit, and an impedance adjustably connected between the anode of each tube and said source.

9. A detector stage comprising a pair of tubes having a common signal input circuit and a common output circuit, means associated with the tubes to operate one as a grid rectifier and the other as a plate rectifier, means for independently adjusting the connection between the grid of each tube and points of high alternating current potential of substantially like phase on said input circuit, and means for independently adjusting the detected outputs of said tubes.

10. A detector stage comprising a pair of tubes having a common signal input circuit and a common output circuit, means for independently adjusting the connection between the grid of each tube and points of high alternating current potential on said input circuit, and means for independently adjusting the detected outputs of said tubes, means for operating one of the tubes as a grid circuit rectifier, means for operating the other tube as an anode circuit rectifier, the detected outputs of said tubes being combined in additive relation in said output circuit.

11. In combination in a radio receiver, a detector stage comprising a pair of tubes having common signal input circuit and a common output circuit, means for connecting the grid of each tube to points of high alternating current potential on said input circuit, means for operating one of the tubes as a grid circuit rectifier, means for operating the other tube as an anode circuit rectifier, the detected outputs of said tubes being combined in additive relation in said output circuit, a carrier wave amplifier having its output coupled to the said common input circuit, and means for impressing upon the said carrier wave amplifier a rectified voltage developed in the grid circuit of said grid rectifier, said rectified voltage varying linearly with applied signal voltage.

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