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VACUUM TUBE DETECTOR

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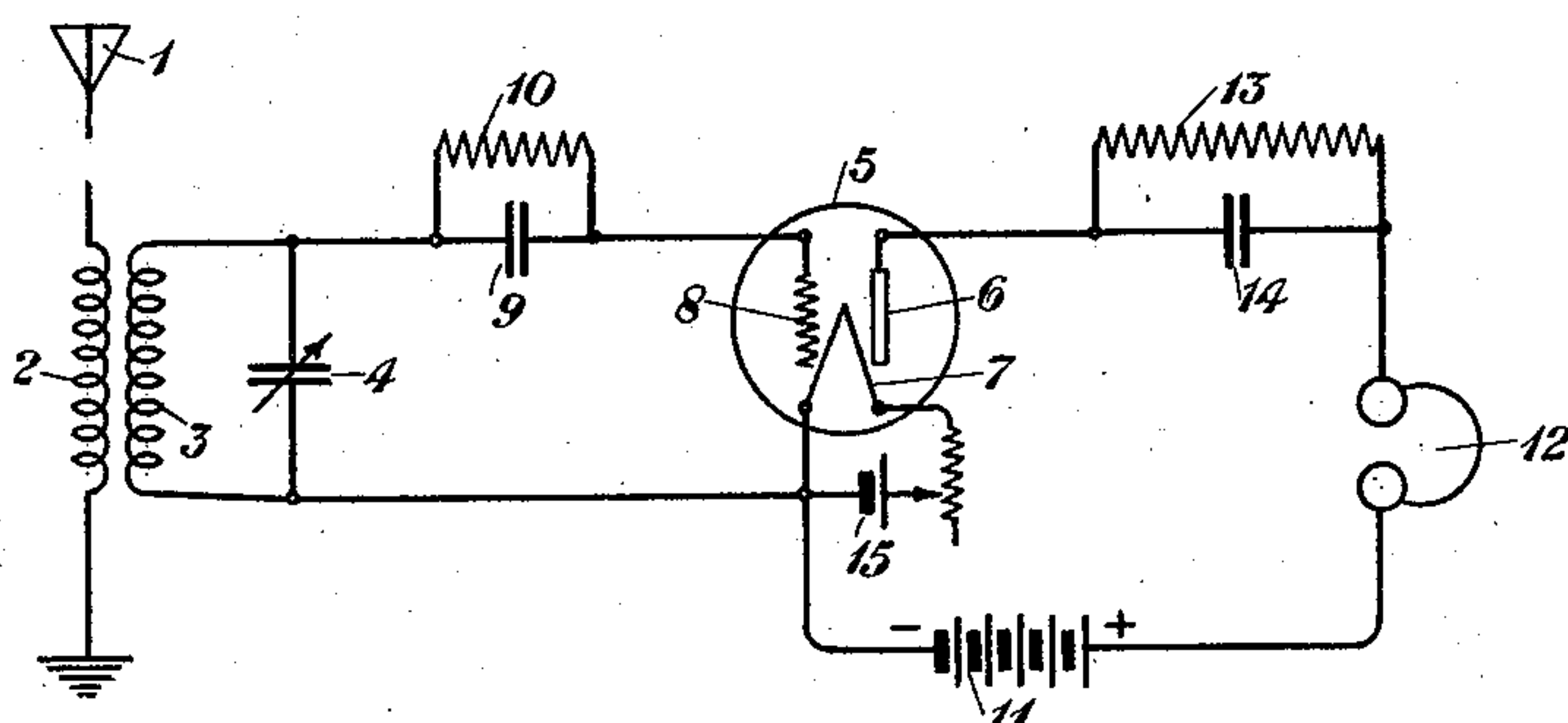


Fig. 1

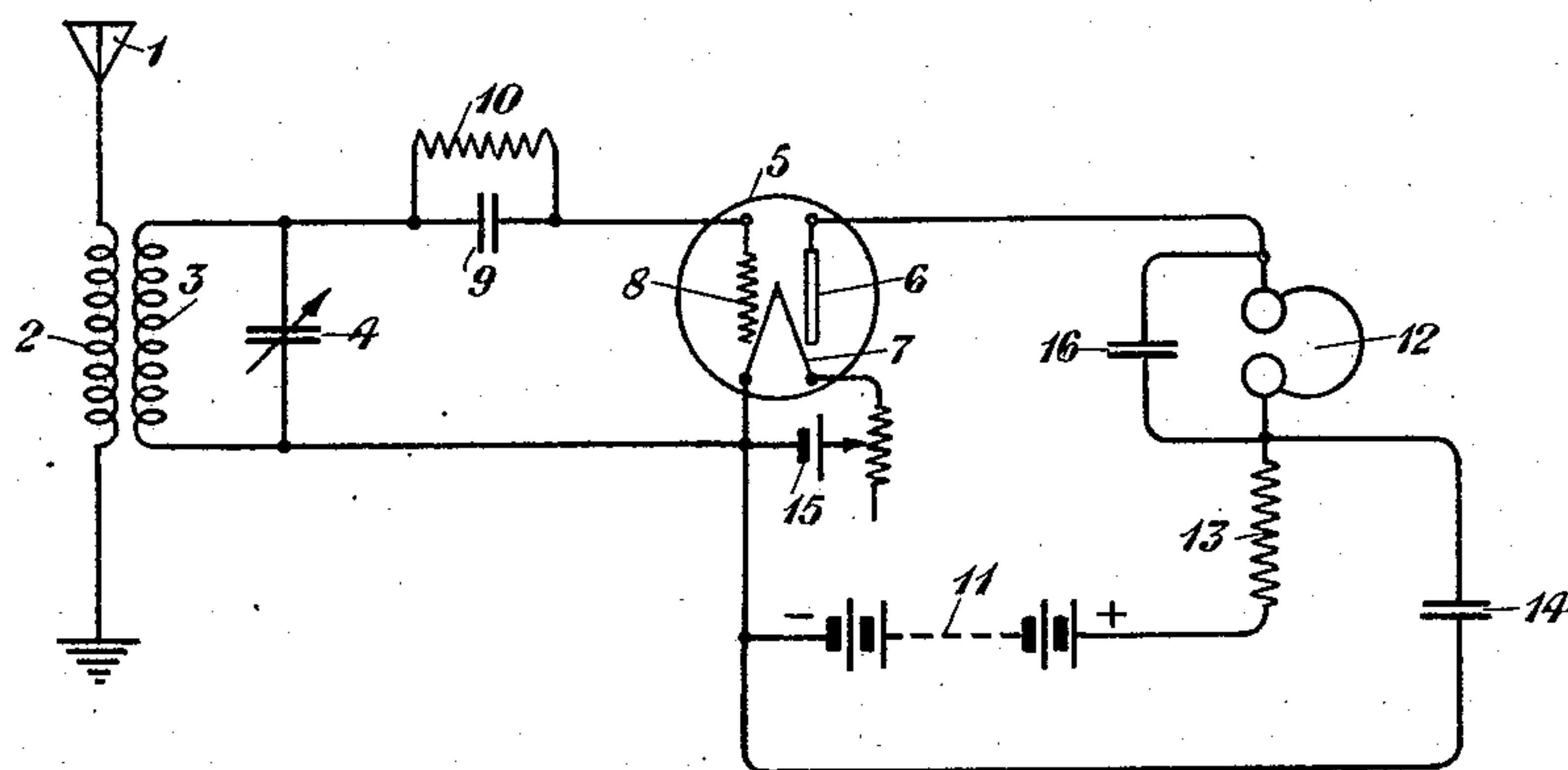


Fig. 2

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VACUUM-TUBE DETECTOR

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This invention relates to vacuum tube grid leak detectors, and more particularly to arrangements for increasing the normal output of a grid leak vacuum tube detector.

5 A vacuum tube consists essentially of a vessel containing a thermionic cathode, generally in the form of a filament heated by passing a current through it, an anode, and a discharge controlling electrode, generally in the form of a wire mesh or grid, which is placed between the cathode and the anode. This discharge controlling electrode may be of any form because a controlling effect on the thermionic emission between the cathode and the anode can be obtained by positioning any conductor with respect to the path, so that potential variations applied thereto will cause variations in the thermionic current between the cathode and the anode.

20 Vacuum tubes of various types are designed for various applications. For use as high frequency amplifiers, it is frequently the practice to use tubes of low or moderate power output, employing grid and plate potentials suitable for satisfactory operation as distortionless amplifiers. Similar tubes are also used as grid leak detectors; but when tubes are so used, the grid potential is ordinarily zero or positive with respect to the cathode. The plate potential is frequently reduced to half the value employed for amplifier operation in order to avoid the possibility of voltage saturation. Such voltage saturation might seriously reduce the detector sensitivity for weak signals. This reduction in the plate potential results in a reduction of the energy output obtainable without distortion from a tube used as a grid leak detector, as compared with that obtainable from the same tube used as an amplifier with the same plate and grid potentials.

It is an object of this invention to provide an arrangement for increasing the power output of a vacuum tube detector.

45 While the nature of the invention will be pointed out with particularity in the appended claims, the invention itself, both as to its objects and features, will be more easily understood from the detailed description hereinafter following when read in connection

with the accompanying drawing showing two embodiments of the invention. Similar parts will be represented by similar reference characters wherever they appear throughout the drawing.

Referring to Figure 1, the antenna or receiving circuit consists of the antenna 1 and an inductance 2 connected to ground. Signals which are to be received are selected by a tuning circuit including an inductance 3 and a variable condenser 4. There is shown a vacuum tube 5 of the three-electrode type, having an anode 6, a cathode 7 and a discharge controlling electrode 8. The input circuit for this vacuum tube includes the cathode 7 and the discharge controlling electrode 8, and is connected to the tuning circuit including inductance 3 and the variable condenser 4 through a grid condenser 9 and a high resistance leak 10. The output circuit of this vacuum tube includes the anode 6, the cathode 7, a source of electromotive force 11, a telephone receiver 12 and a resistance 13. The condenser 14 shunts the resistance 13 for alternating current components of the plate current. A battery 15 is employed for heating the cathode 7 of the vacuum tube 5 to incandescence.

In the circuit shown in Fig. 1, when no oscillations are being received by the grid leak detector, a steady current flows in the output circuit, and the potential existing between the anode and the cathode is the potential of the source minus the drop in potential due to the resistance connected in the output circuit. Also, a small direct current ordinarily flows in the input circuit since the grid is normally at a positive potential with respect to the negative end of the cathode, which potential is determined by the potential drop across the cathode minus the potential drop in the grid leak resistance caused by the flow of grid current therethrough. The grid or discharge control electrode then assumes the approximate potential corresponding to the part of the cathode to which this circuit is connected.

When the antenna circuit becomes energized by incoming oscillations, an oscillatory current is set up in the tuned circuit, and an

alternately positive and negative electromotive force appears across the terminals of the condenser in the input circuit. This alternately charges the discharge controlling electrode positively and negatively. During the part of the cycle in which the discharge controlling electrode becomes positive, some of the electrons present in the tube are attracted by the discharge controlling electrode. During that part of the cycle in which the discharge controlling electrode becomes negative, none of the electrons are removed from the discharge controlling electrode, and a negative charge thus builds up thereon. This has the effect of accumulating a negative charge on the discharge controlling electrode which acts so as to decrease the normal electronic current flowing between the cathode and the anode. It is therefore necessary to include a high resistance leak in the input circuit so as to provide a path by which the charge on the discharge controlling electrode may leak back to the cathode. This permits the potential of the grid to vary at voice frequencies but not at carrier frequencies because of the time constant of the grid condenser and leak circuit.

Arrangements which are used for detecting signals employing a grid condenser and leak operate at any point of the well-known static characteristic curve. Thus the adjustment of the grid potential which is necessary in other systems is eliminated and this therefore simplifies the operation, but the greatest sensitivity is obtained when the grid leak detector is operated at the midpoint of the static characteristic curve, the point at which the slope is greatest.

In fact, rectification actually takes place in the input circuit of a grid leak vacuum tube detector, and the vacuum tube is employed for amplifying the signals. The variations of the current in the output circuit are greater than the variations of the current in the input circuit.

In order to increase the available output of a vacuum tube for an increased current in the input circuit, it is necessary to increase the potential of the source connected in the output circuit. In accordance with this invention, the source of potential 11 is higher than that normally employed in connection with a detector tube, and the resistance 13 is connected in series with the source of potential 11 so as to cut down the potential impressed between the anode and the cathode of the vacuum tube 5 for low input levels. When the tube functions as a detector for high input levels, the plate current, which would be normally reduced, does not incur such a great change by virtue of the ratio that the resistance 13 bears to the resistance in the rest of the output circuit. Assuming that R is the magnitude of the resistance 13 in ohms, that E_1 is the difference of potential existing

between the anode and the cathode of the vacuum tube 5 in volts, that E_2 is the potential of the source of electromotive force 11 in volts, and that I is the current flowing in the output circuit of the vacuum tube 5 in amperes, then when there is no resistance in the output circuit, the potential existing between the anode and the cathode, E_1 , is equal to the electromotive force of the source E_2 . An alternating current present in the input circuit produces variations in the current in the output circuit about that part of the static characteristic curve at E_2 . When the resistance 13 is present in the output circuit of the vacuum tube 5 and the current I flows therethrough, then the electromotive force E_2 of the battery 11 equals the potential drop across the resistance 13, RI , plus the potential difference existing between the anode and the cathode of the vacuum tube 5, E_1 . Thus

$$E_2 = RI + E_1 \quad (1)$$

and therefore,

$$R = \frac{E_2 - E_1}{I} \quad (2)$$

E_1 being the difference of potential between the anode and cathode of the vacuum tube 5. Also, when the current in the output circuit I increases, the potential existing between the anode and the cathode of the vacuum tube 5, E_1 , will decrease, and conversely, when the current in the output circuit decreases, the potential existing between the anode and the cathode increases.

The greater the resistance R included in the output circuit of the vacuum tube, the greater will be the variation in the potential existing between the anode and the cathode of said tube brought about by a variation in the potential impressed between the anode and control electrode of the tube. If the resistance 13 were of infinite magnitude, and the supply of voltage were also infinite, there would be no change in the current flowing in the output circuit of the vacuum tube for all values of the current flowing in the input circuit of the vacuum tube.

In this invention, when the current flowing in the input circuit of the detector increases, greater current flows in the output circuit of the detector than would otherwise flow in the output circuit of this detector if an ordinary potential were connected therein. The drop in potential is taken up by the resistance 13 when the tube 5 functions as a detector for low input levels. When the tube functions as a detector for high input levels, then the plate current, which would be normally reduced, does not incur a large change due to the presence of the resistance 13. Any plate voltage may be used with this system providing the magnitude of the resistance is adjusted so that it equals that obtained from the expression (2) above, in which E_1 is the

potential for which the tube is designed. When the resistance 13 is very large, the level of the detector approaches the level which would be had if the tube were used as an amplifier.

In Fig. 2 is shown a modification of the arrangements of Fig. 1, in which the same reference characters are used as in Fig. 1 to represent the same parts. In this figure the resistance 13 is connected in series with the source of potential 11 in the output circuit, and the condenser 14 is connected across the terminals of the resistance 13 and the source of potential 11, so as to by-pass alternating current components of the anode current therethrough. A condenser 16 is connected across the terminals of the telephone receiver 12 so as to permit low frequency currents to flow through the telephone receiver 12 and the high frequency currents to flow through the condenser 16. The magnitude of the resistance 13 may be ordinarily determined from the expression (2) given hereinabove, in which E_2 is the potential of the source of electromotive force 11 and E_1 is the plate filament potential for which the tube is designed.

While the arrangements of this invention have been disclosed in certain particular embodiments which are deemed desirable, it is to be understood that it is capable of embodiment in other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a receiving system, a receiving circuit, a tuned circuit coupled thereto, a discharge device having an anode, a cathode and an impedance varying element, said discharge device being connected to said tuned circuit for the rectification of incoming oscillations therein, a telephone receiver connected to said discharge device, and means including a high resistance connected in series with said telephone receiver for increasing the speech level for incoming oscillations of higher amplitudes without thereby causing a material change in the sensitivity of the system for incoming oscillations of lower amplitudes.

2. A system comprising a space discharge device of the three-electrode type, circuit arrangements operatively associated with said device including a grid leak input circuit, an output circuit, a tuned circuit, and means including a resistance in said output circuit for obtaining high output levels for high input levels.

3. In a receiving system, a receiving circuit, a tuned circuit coupled thereto, a vacuum tube having an anode, a cathode and a control electrode, said vacuum tube being coupled to said tuned circuit to permit the rectification of signals therein, a telephone receiver connected to said vacuum tube, and means including a high resistance for in-

creasing the amplitudes of currents flowing through said telephone receiver so as to approach the amplitudes of currents flowing therethrough if the vacuum tube were used as an amplifier.

4. A system comprising a vacuum tube, circuit arrangements operatively associated with said vacuum tube including a grid leak input circuit, an output circuit, a tuned circuit, and means including a resistance and a source of potential in said output circuit for making the output level of the tube approach the output level of the tube used as an amplifier, the potential of said source being substantially higher than that required for good detecting action by the vacuum tube, the circuits being so arranged that the greater the magnitude of the resistance and the greater the potential of the source, the more nearly the output level of the tube approaches the output level of the same tube used as an amplifier irrespective of input levels.

5. A grid leak detector system including a three-element vacuum tube, a high, constant potential plate battery for the vacuum tube, and means to make the output level of the vacuum tube approach the output level of the same tube used as an amplifier.

6. In a radio receiving circuit, an antenna circuit, a three-element vacuum tube, a grid leak input circuit for said tube tuned to said antenna circuit, a receiver, an output circuit for said tube tuned so that signals are heard in said receiver, and means including a high resistance in series with said receiver for increasing the current in said receiver beyond the current normally obtainable with the same tube used as a detector.

7. In combination, a three-element vacuum tube, a grid condenser, a grid leak, said grid condenser and leak being included in the input circuit of said tube, a battery of higher potential than that normally required for proper action of the vacuum tube as a detector, and a resistance, said battery and said resistance being included in the output circuit of said tube, the fluctuating direct current in the output circuit increasing as the magnitude of the grid current increases.

8. A receiving circuit comprising a discharge tube of the three-electrode type, a grid condenser and leak, said grid condenser and leak being included in the input circuit of said tube, a battery, and a resistance, said battery and said resistance being included in the output circuit of said tube, the ratio that said resistance bears to the total resistance of the output circuit alternately increasing and decreasing as the amplitude of the waves impressed on said input circuit decreases and increases.

9. In a radio receiving circuit, an antenna circuit, a condenser, a grid leak, a vacuum tube having an anode, a cathode, and a grid, the input circuit for said vacuum tube in-

cluding the cathode and grid of said vacuum tube and said condenser and grid leak, said input circuit being coupled to said antenna circuit, a high resistance, a high potential battery, the potential of said battery being substantially higher than that required when the vacuum tube is acting merely as a detector, and a receiver, the output circuit for said vacuum tube including said resistance, said high potential battery and said receiver.

10. A radio circuit comprising a vacuum tube having an anode, cathode and a control electrode, an input circuit including said cathode and said control electrode for the rectification of signals therein, an output circuit including said cathode and said anode which has a high potential source of current and a resistance therein of such magnitude that the output level is at a maximum for all input levels.

11. A detector for signaling systems including a source of potential of a magnitude several times as large as is normally required for good detecting action and a high resistance in series with said source of potential, said source of potential and said resistance being so related to the detector that detected signals have maximum audibility without appreciable distortion.

12. A three-electrode vacuum tube system comprising means for increasing the audibility of signals detected thereby by any predetermined amount without appreciable distortion, said means including in series relationship a high potential source of plate current of a magnitude substantially greater than that ordinarily required for normal detecting action and a high resistance.

In testimony whereof, I have signed my name to this specification this 8th day of December, 1925.

RUSSELL S. OHL.