May 9, 1933. C. TRAVIS 1,908,381

RADIO RECEIVING SYSTEM

Original Filed Aug. 1, 1930

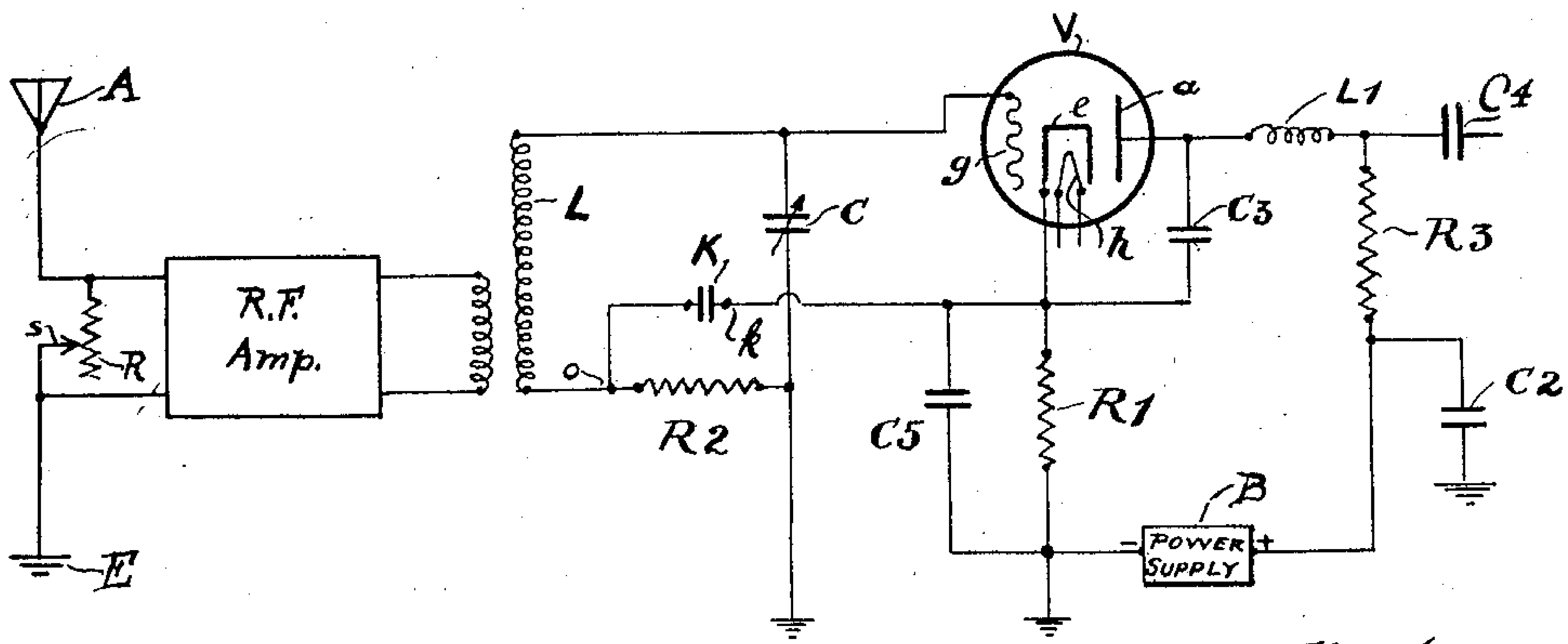

Fig. 1.

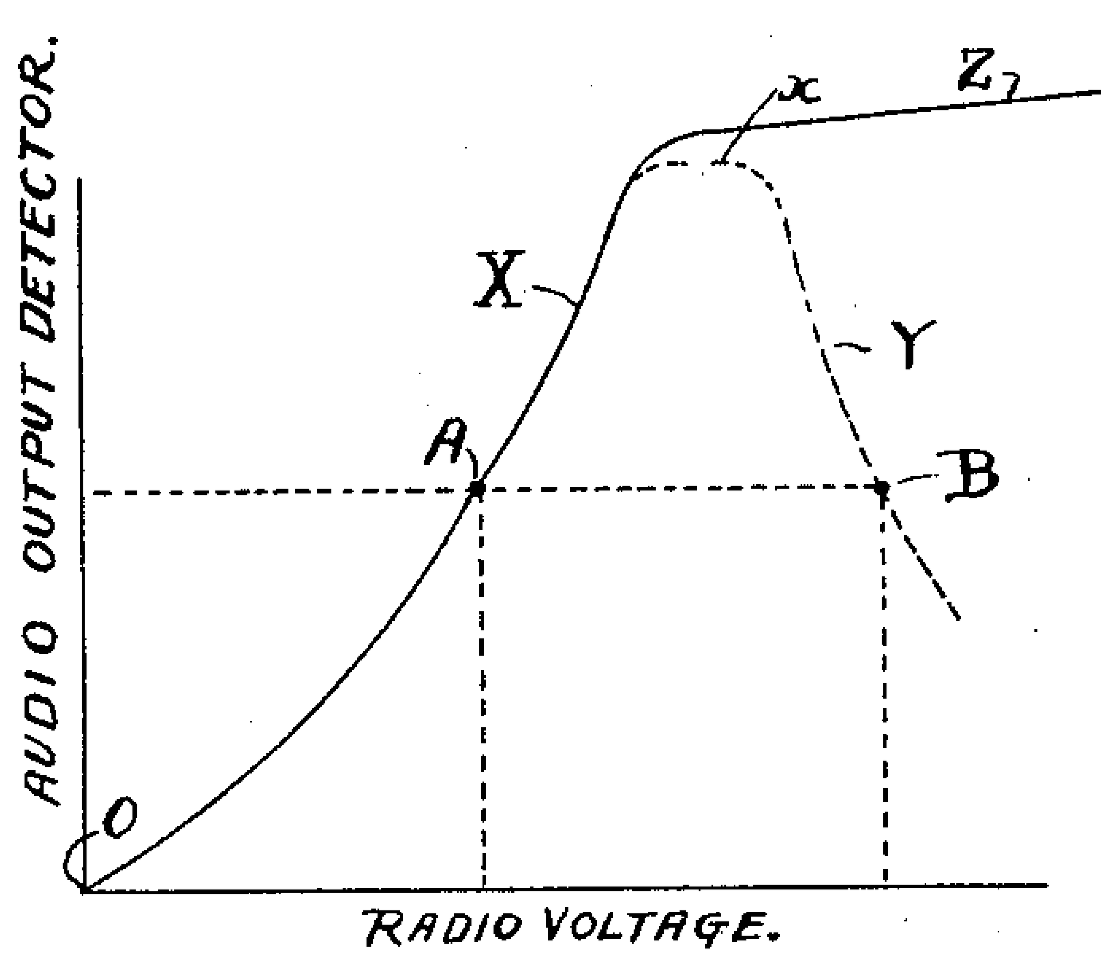

Fig. 3

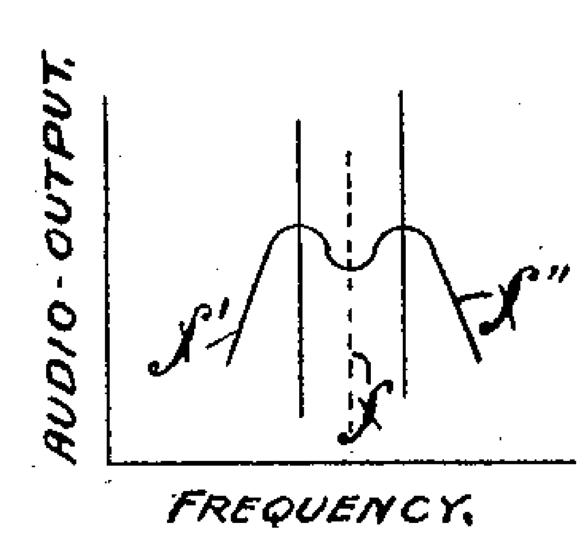

Fig. 2

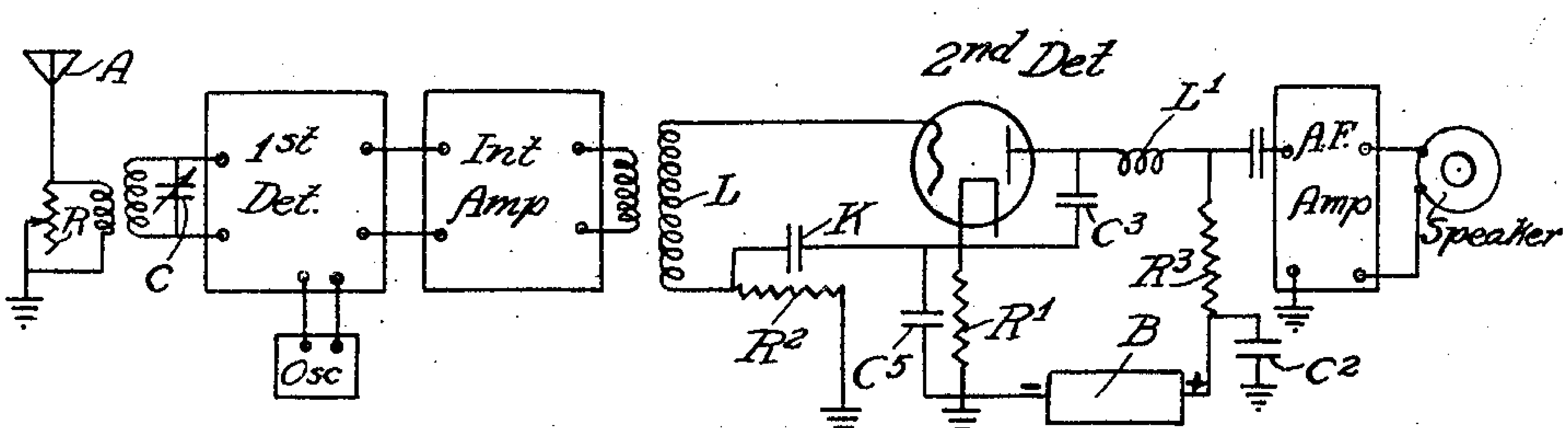

Fig. 4.

INVENTOR.

Charles Travis

BY Cornelius D. Ehret

his ATTORNEY.

Patented May 9, 1933 **1,908,381**

UNITED STATES PATENT OFFICE

CHARLES TRAVIS, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO ATWATER KENT MANUFACTURING COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA

RADIO RECEIVING SYSTEM

Application filed August 1, 1930, Serial No. 472,378. Renewed March 25, 1933.

My invention relates to radio receiving systems and particularly to the detection or rectification of modulated signal energy.

In accordance with my invention, to overcome slumping of the radio-input audio-output characteristic of a thermionic detector, the input energy is utilized automatically to bias the grid of the detector tube increasingly negative as the radio-frequency input increases and with avoidance of degenerative feed-back effects; more particularly, there is included in the detector input circuit a network, specifically a combination of resistance and capacity, whose time constant is greater than the period of the lowest frequency of the detector output, from which is derived the automatically variable grid-biasing potential, the network being so included in the detector system that it is effective to prevent the audio-frequency variations of the detector anode current from effecting variation of the grid potential at the frequencies of modulation.

Particularly and more specifically, a portion of the input radio-frequency energy, especially when of high amplitude is rectified and utilized for steady or grid biasing purposes, and the audio-frequency variations of plate current resulting from rectification in the plate circuit of the detector and corresponding to the modulation of the radio-frequency input energy is prevented from effecting variation of the grid potential, at audio-frequency.

For an understanding of my invention and for illustration of a form which it may take, reference is to be had to the accompanying drawing in which:

Fig. 1 diagrammatically represents radio receiving apparatus utilizing my invention.

Figs. 2 and 3 are explanatory curves.

Fig. 4 illustrates a superheterodyne receiver utilizing the invention.

Referring to Fig. 1, radio frequency energy received, for example, by the antenna A is impressed upon the input circuit element L of the detector tube V which is a power detector or one utilizing anode circuit rectification. As indicated, there may intervene between the input circuit of the detector and the antenna, a radio frequency amplifier of one or more stages whose input circuit is connected to the antenna and to earth E or equivalent counter capacity. The input circuit of the detector tube V may be tuned by the variable condenser C, and the input circuit or circuits of the amplifier similarly or otherwise tunable to the frequency of the incoming carrier energy, or as in Fig. 4, the amplifier and detector input circuit may be tuned to an intermediate frequency, corresponding to the beat frequency between an oscillator and the carrier frequency impressed upon the input circuit of a detector preceding the radio frequency amplifier.

Adjustment of the slider *s* along the resistance R connected in the antenna path controls the amplitude of energy impressed upon the input circuit of the detector tube V, and, therefore, the amplitude of volume of signals reproduced by apparatus, as a loud speaker, associated with the output system of the detector. In so far as this invention is concerned, the volume of reproduced signals may be varied in any known way for controlling the amplitude of the signal energy supplied to the detector input circuit.

The positive terminal of the power supply B, which may be a battery or a rectifier, which may have a voltage of 180 volts more or less, is connected to the anode *a* of the tube and the negative terminal is connected through a resistance R1 to the cathode *e* of the tube. The plate potential may be about 40 or 50 volts above cathode potential. The grid *g* of the tube is conductively connected through the inductance L of the input circuit to the negative terminal of the B battery which, as indicated, may be grounded. The grid of the tube is at a potential always lower than that of, or is negative with respect to, the cathode *e* by virtue of the voltage drop across resistance R1 due to flow of anode current. The negative biasing of the grid may, however, be obtained any other known ways.

In the operation of radio receiving apparatus, using anode circuit rectification, as in power detectors, it has been found that, as shown graphically in Fig. 3, the audio output increases with increase of received signal energy, as from O along the curve X to a region such as x, and then when the radio voltage impressed upon the detector input circuit further increases, the audio output decreases, as indicated by the dotted portion Y of the curve. It may occur, for example, that when the system is receiving a signal of higher intensity, represented for example by the biasing of the point A, and then there is received a different, but more powerful signal, whose strength is represented for example by the biasing of the point B, the amplitude or volume of the reproduced signals, as effected by a loud speaker or the like, is the same for both the weaker and stronger signals. Or assuming a certain amplitude of received signal energy, and a certain setting of a volume control, such for example, as the contact s on resistance R, the audio output may have a magnitude corresponding with the ordinate of the point A, or the audio output may correspond with the ordinate of the point B, as when the contact s be moved to some other position corresponding with materially greater signal voltage impressed upon a detector input circuit. One disadvantage of this characteristic of power detectors, is that the quality of reproduction corresponding with the stronger signals, or generally greater radio voltage impressed upon a detector input circuit, for which the audio output has the magnitude indicated by the drooping portion Y of the curve, is poor, or at least inferior to that corresponding with operation upon the portion X of the characteristic curve.

In accordance with my invention, by suitably controlling the grid bias of the detector tube, the radio-input audio-output characteristic curve of Fig. 3 is modified to comprise the portion X, as before, with the portion Z, for all points on which, at least within the vicinity of the upper end of the portion of the curve X and materially beyond, the audio output does not decrease, though it does not as rapidly increase, with increase in radio-input as upon the portion X; and accordingly the situation does not arise, as before explained, that for different magnitudes of radio-input there may be the same magnitudes of audio-output.

Furthermore, slumping of the radio-input audio-output characteristic beyond the region X also gives rise to the phenomena of an apparent double peaked resonance or tuning curve. As illustrated by Fig. 3, when the apparatus is tuned to a frequency f, and the signal energy is of such strength that due to resonance the radio-frequency potential impressed upon the input circuit of the detector V is at its maximum and corresponds to a point on the portion Y of the characteristic, the audio-output of the detector, and, therefore, the volume of reproduction, is substantially less than that of signals to which the set has not been tuned, but which give rise to radio frequency voltages in the input circuit which corresponds with points on the portion X of the characteristic curve.

This effect is experienced both when the selection of signal is effected by tuning of the detector input circuit or when the detector input circuit is not tunable and the selection is effected prior to the detector, as, for example, when the tunable circuits comprise or are ahead of the input circuit of the first detector of a superheterodyne receiver.

In as much as the operator in tuning a set makes an adjustment which effects maximum amplitude of reproduction, he would not, as indicated by Fig. 2, tune to the frequency f of the desired signal, for he would not know when his adjustment corresponded with resonance with the frequency f, since his audio-output or amplitude of reproduction is at a maximum for some other frequency, such as f' or f'', either higher or lower than the frequency f. In seeking maximum response, the operator, therefore, has unconsciously detuned his set away from frequency f, with the result, as regards the desired signal, he has impaired quality and increased the likelihood of interference from other stations.

In accordance with my invention, the automatic control of the grid bias of the detector tube which prevents the falling off of audio-output for high radio input voltages and modifies a characteristic curve to comprise the portion Z, ensures maximum amplitude of reproduction for resonance at the frequency of the desired signal.

Referring to Fig. 1, there is included in the input circuit of the detector tube V, a resistance R2 of suitably high magnitude, which is shunted by a condenser K of low reactance to currents of radio-frequency. The condenser C5, which is in series with condenser K in shunt to resistance R2, is of such low impedance to currents of radio-frequency that it may be considered for the following explanation that the condenser K is directly in shunt to resistance R2. The time constant of the network, comprising the resistance R2 and condenser K, is greater than the time period of the lowest frequency of modulation of the impressed signal energy, or in any event, preferably greater than the lowest frequency which is reproduced, as by a loud speaker associated with the detector output circuit. An equivalent of the network would be a leaky condenser having the proper values of resistance and capacity. By way of example, only, resistor R2 may have a value of the order of .5 megohm, and the condenser K a capacity of .1 microfarad.

When for strong radio-input voltages, the grid is positive for a small fraction of a cycle, there is produced from the input signal energy in the input circuit, due to the assymetrical conductivity between the grid g and cathode e, a small unidirectional current component or uni-directional current impulses, which by virtue of the condenser K and its related resistance R2, is a substantially direct or continuous current, effecting, between the terminals of the resistance R2, a potential difference which negatively biases the grid g. The negative bias so imposed upon the grid g has the effect that the characteristic curve of Fig. 3 is converted from the combination XxY to XZ, with the result, previously indicated, that for strong incoming signals, or for suitable manipulation of a volume control, the audio output does not slump or decrease; and with the further result that maximum audio output occurs at resonance, if the set is tunable to the received signal energy.

When additional means are utilized for negatively biasing the grid, as the resistance R1, or any equivalent means, the total negative bias upon the grid g, is the sum of the biases effected by the resistance R1, and the network K, R2. Whether or not the additional grid biasing means are utilized, the relation should be such that for radio frequency signal energy of high amplitude, the negative grid bias is sufficient to prevent the detector operating upon that portion of the grid-voltage plate-current characteristic which corresponds to a decreasing ratio of plate current to grid voltage, which latter, if obtaining, yields the portion Y of the characteristic curve of Fig. 3.

The direct or continuous grid current due to received signal energy and traversing resistance R2, is always of such small magnitude that the selectivity of the tuned or tunable circuit L, C is not appreciably impaired. This automatic negative grid bias remains substantially constant for any given signal strength, and does not vary in magnitude with the modulation, since the time constant of the biasing network R2, K is greater than the period of the lowest frequency of modulation. For the values of R2 and K, given above, the time constant (which is dependent upon the product of the resistance R2 and the capacity of K) is .05 second, which corresponds to the period of a current of a frequency of 20 cycles per second, and is therefore greater than the period of the lowest frequency usually sought to be preserved in the reproduction of sound.

The normal bias of grid g, in the example given, may be about 8 volts, the drop across resistance R1, which may have a value of about 40,000 ohms, but upon reception of a strong signal, the bias is automatically increased by resistance R2 and condenser K, for example, to as high as 60 volts, depending upon the strength of signal.

The negative grid bias, derived from the received signal energy, does not instantly disappear upon cessation of that energy, but decreases to a certain fraction of its former magnitude within a certain time, which is the period or time constant of the network K, R2, whatever may have been the amplitude of the received energy. If, therefore, the time constant of the network were made too great, as of the order of several seconds, the receiving apparatus would be for such length of time out of condition to receive weak signals, to which, within such period, the operator might seek to tune the apparatus. Hence, from the standpoint of speed of use in the hands of the operator, it is desirable that the aforesaid time constant be not too great, and on the other hand, it is desirable that it be not too short, that is, it should not be shorter than the period of the lowest frequency of modulation of the radio-frequency energy received. Otherwise, there would occur variation of the negative grid bias, due to and effected by the received energy in the input circuit of the tube.

That is, the grid bias would not remain substantially constant for a given signal strength, but would vary at an audio-frequency.

It is characteristic of my system, that a portion of the input-radio frequency energy, especially when of high amplitude, is rectified in the input circuit of the tube and utilized for steady or direct negative grid bias purposes. If the received energy is modulated, the rectification occurring in the plate circuit of the detector, produces a plate current component corresponding with the modulation of the received energy.

As the resistance R1 is traversed by audio frequency current resulting from plate circuit rectification, there is a tendency for the grid of the tube which is connected to one end of the resistance while the cathode e is connected to the other, to vary at the frequencies of modulation with respect to the cathode. This, if not checked, would result in degeneration and in general, unsatisfactory operation of the apparatus.

Though the terminal k of the condenser K is substantially at the same potential as the grounded terminal of the resistance R2 for radio-frequency, because of the negligible impedance of condenser C5 for radio-frequencies, there exists between these points which are connected to the cathode e and ground respectively, a potential varying at modulation frequencies due to the flow of the rectified current in the anode circuit of the tube V. The terminal of the input element or inductance L, remote from the grid g is connected to a point o whose potential because of the filtering action effected by the condenser K, and R2, remains substantially constant insofar as audio or modulation frequencies are concerned. The audio frequency variations of current in the plate circuit cause audio-frequency variations of potential of cathode e with respect to earth E, or equivalent. The connection of the grid g to earth through high resistance R2 and the connection of point "o" through the low impedance of capacity "K" prevents this variation of the potential of cathode e from causing the potential of the grid g from varying with respect to cathode e. In effect, the potential of grid g varies the same as the potential of cathode e. Thus the combined effects of resistance R2 and condenser K provide a filter action which eliminates the degenerative effect of resistance R1. De-generation or feed-back because of inclusion of the resistance R1 in both the audio output and radio input circuits of the tube, is substantially reduced or eliminated. Because of the effectiveness of the filtering action of the network, which is in addition to its action as a source of automatic grid biasing potential, the audio-frequency by-pass condenser C5, may be of much less magnitude than if the condenser K were connected directly in shunt to resistance R2, as by transferring the connection from the point k, to cathode, to the grounded end of resistance R2. For example, the condenser C5 of Fig. 1, when having a capacity of .1 microfarads, is equal in effectiveness in preventing variation of the grid potential at modulation frequencies, to a condenser of 20 times that value when the condenser K is connected directly in shunt to resistance R2 instead of between the point o and cathode e.

Although the resistance R2 is included in the tuned or tunable loop L, C, its damping effect is practically negligible since the condensers K and C5 in series afford a radio-frequency path of low impedance in shunt to it.

The particular tube shown is of the unidirectional cathode type such as a UX227, whose cathode e is raised to a temperature at which the electrons are emitted by a heater h connected to a suitable source of current, for example, a battery or the low potential secondary, of a power transformer. However, it will be understood that there may be used other types of tubes including those whose cathodes are themselves traversed by heating current, either direct or alternating.

The output circuit of the detector may be coupled to the input circuit of an audio amplifying system in any known manner; by a transformer, an impedance, or as indicated, by resistance. The plate a of the detector tube is connected to the upper terminal of the coupling resistance R3 of suitably high magnitude whose lower terminal is connected to the positive terminal of the power supply, the condenser C2 affording a path to earth of low impedance to audio frequency currents. Preferably, radio frequency currents are excluded from coupling resistance R3 by a filter network comprising the radio frequency choke L1 and a radio frequency by-pass condenser C3 connected between the anode a and cathode e. The high potential end of the coupling resistance may be connected in the usual manner through a blocking condenser C5 to the input circuit of a subsequent tube.

Although one terminal, for example, the rotor terminal, of the variable condenser C is preferably connected to ground to avoid detuning effects due to body capacity and to facilitate mechanical coupling to the rotors of other variable condensers, it will be understood that it may be connected to the point o or to the cathode e.

What I claim is:

1. In the art of rectifying modulated radio-frequency energy by a thermionic detector tube having biasing means common to the input and output circuits thereof, the method which comprises, impressing modulated radio-frequency signal-energy upon the input circuit of said tube, deriving from said radio-frequency energy in the input circuit of the tube by a combination of resistance and capacity solely in the input circuit of the tube a steady negative grid biasing potential, rectifying the signal energy in the anode circuit of said tube to produce variation of the anode current at modulation frequencies, and substantially eliminating by said combination of resistance and capacity variation of the grid potential at modulation frequencies by said variations of anode current in said biasing means.

2. Radio receiving apparatus comprising a detector tube having an input circuit, means for impressing modulated radio-frequency energy upon said input circuit, means for deriving a substantially steady grid biasing potential from said impressed energy comprising an impedance network solely in said input circuit, impedance common to the input and output circuits of said tube, and means for preventing audio-frequency-variations of current traversing said impedance from effecting audio-frequency variation of the potential of the grid of said tube comprising said network.

3. Radio receiving apparatus comprising a detector tube having an input circuit, means for impressing modulated radio-frequency energy upon said input circuit, a conductive impedance traversed by the anode current of said tube, a conductive impedance of high magnitude connected between the grid and cathode of said tube external to the path of anode current and in series with said impedance and traversed by said impressed radio-frequency energy in the input circuit of said tube, and a condenser of low impedance to currents of radio-frequency in shunt to said series-connected impedances, said condenser and said second impedance comprising a network for producing a grid biasing

potential of magnitude to prevent slumping of the radio-input audio-output characteristic of the detector and to prevent degeneration by precluding variation of the grid potential at the modulation frequencies of said radio-frequency energy.

4. Radio receiving apparatus comprising a detector tube, a closed loop comprising series-connected conductive impedances and a condenser of low impedance to radio-frequency currents in shunt to said impedances in series, connections from the common terminals of said impedances to the anode of said tube, and connections from the other terminals of said impedances to the grid and cathode of said tube, one of said impedances deriving a grid biasing potential from the anode current of said tube, and the other of said impedances and said condenser deriving a steady grid biasing potential from the input signal energy and preventing variation of the first biasing potential at the modulation frequencies of the rectified signal energy.

5. Radio receiving apparatus comprising a detector tube having an input circuit, means for impressing modulated radio-frequency energy upon said input circuit, a conductive impedance in the anode circuit of said tube traversed by the direct and audio-frequency components of the anode current, a conductive impedance connected between the grid of said tube and the low potential terminal of said first impedance external to the path of anode current, and a condenser connected between the grid of said tube and the high potential terminal of said first impedance, said condenser and said first impedance forming a network whose time constant is greater than the lowest reproduced audio-frequency of anode current for steady grid-biasing purposes, and which prevents degeneration by precluding variation of the grid potential by the audio-frequency variations of anode current traversing said second impedance.

6. Radio receiving apparatus comprising a power detector tube having an input circuit, means for impressing modulated radio-frequency upon said input circuit, a source of anode current, a resistance connected between the cathode of said tube and the negative terminal of said source of anode current, a resistance connected between the grid of said tube and said negative terminal external to the path of anode current, and a condenser connected between the grid and cathode of said tube, said condenser and said second resistance deriving a steady grid biasing potential from the signal energy and preventing the audio-frequency variation of anode current through said first resistance due to plate circuit rectification of said modulated radio-frequency energy from effecting corresponding audio-frequency variation of the grid potential thereby substantially preventing degenerative effects.

7. Radio receiving apparatus comprising a detector tube, a resistance connected between the cathode and anode of said tube, and an input circuit comprising an inductance having one terminal connected to the grid of said tube and whose other terminal is connected to the cathode and anode terminals of said resistance by a condenser and a second resistance respectively, said condenser and second resistance comprising a network for deriving a steady grid-biasing potential from the radio-frequency signal energy in said input circuit and preventing audio-frequency variations of the anode current traversing said first resistance from effecting corresponding variations of the grid potential.

8. Radio receiving apparatus comprising a detector tube, a resistance connected between the cathode and anode of said tube, and an input circuit tunable to the frequency of modulated radio-frequency energy by variable capacity and comprising an inductance having one terminal connected to the grid of said tube and whose other terminal is connected to the cathode and anode terminals of said resistance by a condenser and a second resistance respectively, said condenser and second resistance comprising a network for deriving a steady grid-biasing potential from the radio-frequency signal energy in said input circuit and preventing audio-frequency variations of the anode current traversing said first resistance from effecting corresponding variations of the grid potential.

9. A superheterodyne receiver comprising a second detector tube, a resistance connected between the cathode and anode of said tube, and an input circuit tuned to the intermediate frequency of said receiver and comprising an inductance having one terminal connected to the grid of said tube and whose other terminal is connected to the cathode and anode terminals of said resistance by a condenser and a second resistance respectively, said condenser and second resistance comprising a network for deriving a steady grid-biasing potential from the radio-frequency signal energy in said input circuit and preventing audio-frequency variations of the anode current traversing said first resistance from effecting corresponding variations of the grid potential.

10. Radio receiving apparatus comprising a detector tube having an input circuit, means for impressing modulated radio-frequency energy upon said input circuit, a conductive impedance common to the input and output circuits of said tube and traversed by the anode current to provide a grid-biasing voltage, a condenser in shunt to said impedance for reducing the modulation-frequency drop of potential thereacross, a conductive impedance of high magnitude connected between the grid and cathode of said tube external to the path of anode current and in series

with said first impedance and traversed by the radio-frequency energy in the input system of the tube, and a condenser of low impedance to radio-frequency currents in shunt to the series connected impedances, said condenser and second impedance comprising a network for producing a supplementary steady grid biasing voltage to prevent slumping of the radio-input audio-output of the detector and substantially to eliminate degeneration by precluding variation of the grid potential by the modulation-frequency variations of anode-current traversing said second impedance.

CHARLES TRAVIS.