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RADIO RECEIVING SYSTEM

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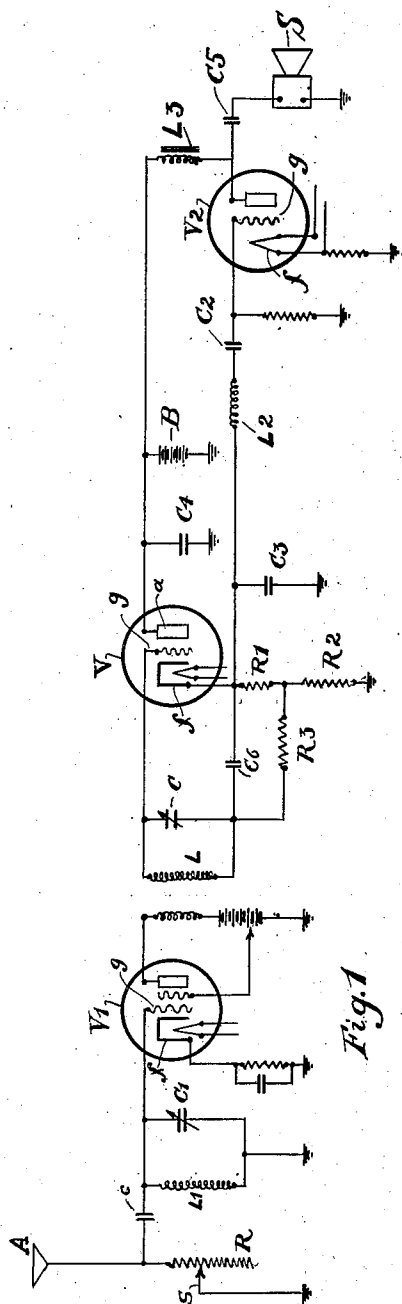


Fig. 1

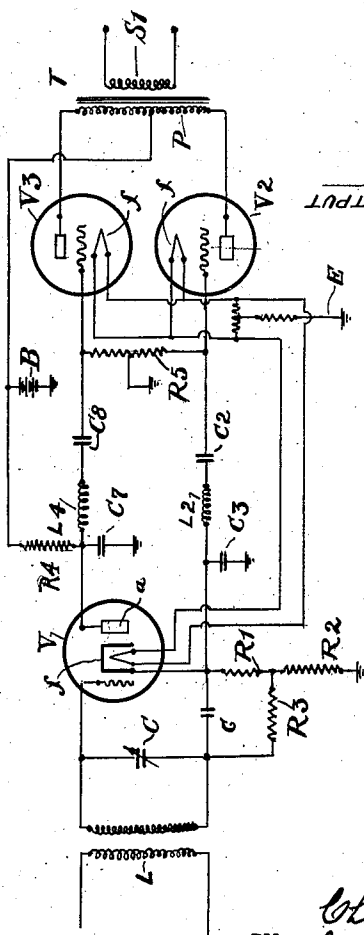


Fig. 4

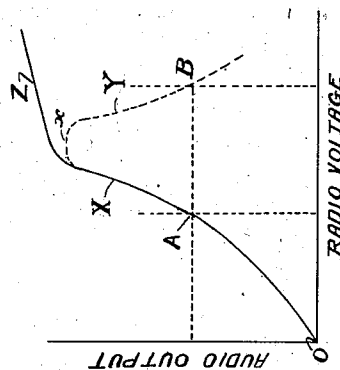


Fig. 2

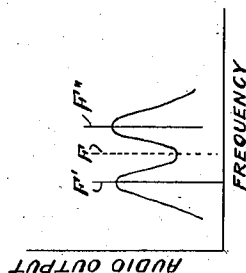


Fig. 3

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## RADIO RECEIVING SYSTEM

Application filed June 7, 1930. Serial No. 459,646.

My invention relates to radio receiving systems, and particularly to the detection or demodulation of the received radio-frequency energy as effected by a thermionic detector tube.

In accordance with my invention, an impedance, specifically a resistance, is interposed between the cathode of a detector tube and ground or equivalent, and the low or audio-frequency variations of potential between cathode and ground arising from flow of current through the resistance are impressed upon a subsequent translating device, such as a low frequency amplifier tube. For push-pull low-frequency amplification, a second impedance is interposed between the anode of the detector tube and ground, and the anode and the cathode of the detector tube connected to the grids of the amplifier tubes.

Preferably the anode circuit direct-current flows through the resistance, and all or any desired part of the voltage drop across it, is utilized to bias the grid of the detector tube to suitable negative value with respect to the cathode for plate circuit rectification. To prevent the grid from varying at audio-frequency and to overcome the disadvantage of plate-circuit rectification that increase of radio-frequency input above a certain value results in decrease of audio-frequency output, the grid return is connected to the cathode through a condenser of low impedance to radio and audio frequency currents, and to the coupling resistance through a suitably high resistance, the condenser and high resistance comprising a network whose time constant is greater than the period of the lowest audio-frequency in the detector output.

My invention further resides in the methods and systems hereinafter described and claimed.

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

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

Figs. 2 and 3 are explanatory curves.

Fig 4 represents diagrammatically, utiliz-

ing a push-pull resistance coupled amplifier in the output circuit of a detector

Referring to Fig. 1, radio frequency energy received by the antenna A is impressed upon the input circuit LC of a detector tube V, there being preferably one or more stages of radio frequency amplification intervening between the input circuit and the antenna. For example, the input circuit L1, C1 of the screen grid tube V1 is connected to the antenna through a small condenser c and to earth E or counter poise. Adjustment of the slider s along the resistance R connected in the antenna path controls the amplitude of the energy impressed upon the detector tube and therefore the volume of signals reproduced by apparatus, as a loud speaker S associated with the tube system of the detector. In so far as the invention herein described and claimed is concerned, the volume of reproduced signals may be varied in any other known way for controlling the amplitude of signal energy delivered to the detector input circuit.

The positive terminal of the power supply B, which may be a battery or a "B eliminator", is connected to the anode a of the detector tube and the negative terminal is connected to the resistances R1, R2, in series, to the cathode f of the tube. While for convenience separate batteries have been shown, it will be understood that the same source may supply the anode current for all tubes of the apparatus. The grids g of the tubes are at a potential always lower than that of or is negative with respect to, the associated cathode f by virtue of the voltage across resistance connected between the cathode f and the negative terminal of the B battery. The negative biasing for the radio frequency amplifier tube V1 and the audio frequency amplifier tube V2 may be obtained in any other known way. The negative bias for the grid of the detector tube V is derived as more fully hereinafter described.

The cathode f of the detector tube or the high potential end of the resistance R1 is connected to the grid g of the audio amplifier tube V2, through the radio frequency choke coil L2 and the blocking condenser C2 of

suitable low impedance for currents of audio frequency. The low potential end of resistance R2 is connected to the cathode of the audio frequency amplifier so that the resistances R1, R2 in series, constitute an input element for the audio amplifier tube, the radio frequency by-pass condenser C3 particularly in combination with the choke L2, preventing the potential of the grid *g* of the audio amplifier tube from varying at radio frequencies. The condenser C4 is of low impedance for currents of audio frequency so that the anode *a* of the detector tube is at ground potential for audio frequency.

The impression of modulated radio frequency signal energy upon the input circuit of the detector tube results in the flow of an audio frequency current corresponding to the modulations of the radio frequency energy, through the resistances R1, R2, producing across the resistances a corresponding audio frequency voltage which is impressed upon the input electrodes of the audio amplifier tube V2 in whose output circuit is included the reproducing apparatus, as the loud speaker S. As indicated plate current may be supplied to the amplifier tube V2 through the audio frequency choke L3, the condenser C5 affording a path to the speaker of low impedance for the audio frequency variations of the anode current.

The flow of direct current through the resistances R1, R2 is utilized to bias the grid *g* of the detector tube V. To that end the lower terminals of the inductance L and tuning condenser C are connected to a suitable point in resistance R1 or R2, or as indicated to a point between them. The by-pass condenser, C6, affords a path of low impedance for radio frequency currents directly to the cathode of the tube. The resistances R1, R2 therefore, have the double purpose of coupling the input circuit of the audio amplifier to the output circuit of the detector tube and of providing negative grid bias for the detector tube.

In the operation of radio receiving apparatus using anode circuit rectification, it has been found that, as shown graphically in Fig. 2, the audio frequency output increases with increase of received signal energy, as from point O along the curve X to a region such as  $\alpha$ , 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, that when the system is receiving a signal of moderate intensity, represented for example by the abscissa of the point A, and then there is received a different but much more powerful signal whose strength is represented, for example, by the abscissa of the point B, the amplitude of 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 as-

suming a certain amplitude of received signal energy, and a certain setting of a volume control, such as for example, 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 the detector input.

A disadvantage of this characteristic of detectors of the type referred to, is that the quality of reproduction corresponding with the stronger signals, for which the audio output has the magnitude indicated by the portion Y of the curve is poor, or at least inferior to that corresponding with operation upon the portion X of the characteristic curve.

By suitably controlling the grid bias of the detector tube, the radio-input audio output characteristic curve of Fig. 2 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 Curve X and materially beyond, the audio output does not decrease with increase in radio input; and accordingly the situation does not arise 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  $\alpha$  also gives rise to the phenomena of an apparent double peaked resonance curve. As illustrated by Fig. 3, when the input circuit 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 is at its maximum and corresponds to a point on the portion Y of the curve of Fig. 2, 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 correspond with points upon the portion X of the characteristic curve.

Inasmuch as the operator in tuning a set makes an adjustment which effects maximum amplitude of reproduction, he would not, as indicated by Fig. 3, tune to the frequency F, of the desired signal, for he would not know when his adjustment corresponded with resonance for the frequency F, since the audio output or amplitude of reproduction is at 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.

These difficulties may be overcome by selecting a suitable value for the high resistance R3. The time constant of the network, comprising the condenser C6 and resistances R3 and R1, is made greater than the time period of the lowest frequency of modulation of the impressed signal energy, or in any event greater than the lowest frequency which is reproduced, as by the loud speaker S. By way of example only, resistor R3 may have a value of the order of 1 megohm, the resistor R1 a value of the order of 40,000 ohms, the condenser C6 a capacity of .1 microfarad and resistor R2, external to the network, a value of the order of 25,000 ohms. Although the condenser C6 is of low impedance for audio frequency currents, it is in series with high resistance R3 across resistance R1, so that substantially all of the audio frequency components of the detector anode current flows through resistance R1. The grid of the detector tube because of the low impedance of condenser C6, and the high magnitude of resistance R3 is, for audio frequencies, at the same potential as the cathode although its direct current potential is negative with respect to cathode.

Due to asymmetrical conductivity between the grid *g* and the cathode, when for strong radio input voltages the grid is positive for a small fraction of a cycle, there is produced in the input circuit a small uni-directional current component or uni-directional current impulses, which by virtue of the network is a substantially direct or continuous current, effecting between the grid and cathode a potential difference which negatively biases the grid, having the effect that the characteristic curve of Fig. 2 is converted from the combination X, *z*, Y to X, Z, with the result, previously indicated, that for very strong incoming signals, or for suitable manipulation of the volume control, the audio output does not slump or decrease; and with the further result that maximum audio output occurs at resonance, if the input system be tunable to the received signal energy.

This bias is in addition to the normal bias derived by flow of the anode current through the resistance R1. The direct or continuous grid current due to the received signal energy and traversing resistance R3 is always of such small magnitude that the selectivity of the tunable circuit L3 is not appreciably impaired. This automatic negative grid bias remains substantially constant for any given signal strength with a given average percentage of modulation, and does not vary in magnitude with the audio-frequency variation in modulation, since the time constant of the biasing network is greater than the period of the lowest frequency of modulation. For the values of C6, R1 and R3, the time constant (which is dependent upon the product of the resistance and capacity) is .1 sec-

ond, which corresponds to the period of a current of a frequency of 10 cycles per second, and is therefore greater than the period of lowest frequency sought to be preserved in the reproduction of sound.

The normal bias of grid *g* in the example given may be about 16 volts, the drop across resistance R1, but upon reception of a strong signal the bias is automatically increased by the network to as high as 30 volts, for example. The negative bias effected by the received signal energy itself, 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. If, therefore, the time constant were made too great, as for example of the order of several seconds, the receiving set 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 receiving system. From the standpoint of speed of use, it is therefore desirable that the time constant of the network be not too great, and on the other hand, it is desirable that it be not too short, that is, shorter than the period of the lowest frequency of modulation.

The anti-slump filter network is claimed in my co-pending application Serial No. 472,378, filed August 1, 1930, in which it is disclosed in circuit with a detector whose cathode is at substantially ground potential.

In the modification of my invention, as shown in Fig. 4, the detector tube V is directly resistance coupled to the push-pull amplifier tubes V2, V3. The audio frequency bypass condensers C4 connecting the anode *a* to earth is omitted and there is substituted therefor a radio frequency by-pass condenser C7. The anode of the tube is connected through the radio frequency choke L4, generally similar to L2, and a blocking condenser C8, generally similar to the condenser C2, to the grid of a second audio amplifier tube V3. The resistance R4 connected for example between the positive terminal of the B battery and the anode of the detector tube is, in magnitude more or less equal to the sum of the resistances of the resistors R1, R2, for example, of the order of 100,000 ohms. The cathodes *f* of the amplifier tubes are as indicated, connected to earth or equivalent E, so that the resistance R4 is effectively in the input circuit of the tube V3 and the resistances R1 and R2 in series are in the input circuit of the tube V2. As indicated there may be provided a grid leak resistance R5, whose opposite terminals are connected to the grids of the amplifier tubes, and to an intermediate point of which connection is made to earth.

In the arrangement described, impression of modulated radio frequency energy upon the input circuit of the detector tube causes flow of audio frequency current through the

resistances R1, R2 and R4 in series. Both the anode and cathode of the detector tube are of audio frequency potentials substantially different from that of the cathodes of the tubes V2 and V3, and which potentials affect in opposite sense the grids of the push-pull amplifier tubes, whose output circuit includes the usual transformer T provided with a split primary P and a secondary S1 for connection to a loud speaker or other translating device.

As in Fig. 1 the grid of the detector tube may be biased by voltage derived from flow of anode current through the resistance R1, and additionally by grid current flowing in the resistance R3.

It will be understood that in the modifications shown the electrode circuits of all tubes may be supplied from a common source of alternating current by means of proper transformers, rectifiers, filter chokes and other accessories as commonly employed in present alternating current operated sets. The filaments or heaters of all tubes may be supplied with current from the same secondary winding of a transformer without in any way interfering with the proper operation of the circuits.

What I claim is:

1. In radio receiving apparatus, a detector tube having anode, cathode, and grid electrodes, a resistance connected between said cathode and earth and traversed by low frequency currents in the anode circuit of said tube, a connection of low impedance to low frequency current between the anode of said tube and earth to increase the low frequency drop of potential across said resistance, and a translating device responsive to low frequencies including said resistance in its input circuit.

2. In a radio receiving apparatus, a detector tube having anode, cathode and grid electrodes, a resistance connected between said cathode and earth, a condenser in shunt thereto of low impedance to currents of radio frequency, a path of low impedance to currents of low frequency between the anode of said tube and earth for increasing the low frequency drop of potential across said resistance, and a translating device responsive to low frequencies including said resistance in its input circuit.

3. In a radio receiving apparatus, a detector tube having anode, cathode, and grid electrodes, a source of direct current anode potential, a resistance connected between said cathode and the negative terminal of said source, a connection from a point of said resistance remote from the cathode to said grid to effect negative biasing thereof, a condenser in shunt to said resistance of low impedance to currents of radio frequency, a condenser between said anode and the low potential end of said resistance of low im-

pedance to currents of audio frequency to increase the audio frequency drop of potential across said resistance, and a translating device responsive to audio frequencies including said resistance in its input circuit.

4. A radio receiving apparatus, a thermionic detector tube having anode, cathode, and grid electrodes, a resistance connected between the cathode of said tube and earth, a second resistance substantially equal in magnitude to said first resistance and connected between the anode of said tube and earth, and a pair of audio amplifier tubes having their cathodes connected to earth and their grids connected respectively to the cathode and anode of said detector tube.

5. In radio receiving apparatus, a thermionic detector tube having anode, cathode, and grid electrodes, a resistance connected between the cathode of said tube and earth, a second resistance substantially equal in magnitude to said first resistance and connected between the anode of said tube and earth, a pair of thermionic amplifier tubes having their cathodes connected to earth and their grids connected respectively to the cathode and anode of said detector tube, and a common source for rendering the cathodes of said detector and amplifier tubes electron emissive.

6. In radio receiving apparatus, a thermionic detector tube having anode, cathode and grid electrodes, a source of direct current anode potential, a resistance connected between the negative terminal of said source and the cathode of said tube, a second resistance substantially equal in magnitude to said first resistance and connected between the positive terminal of said source and the anode of said tube, a pair of thermionic amplifier tubes having their grids connected respectively to the cathode and anode of said detector tube, and connections from their plates and cathodes to the positive and negative terminals of said source respectively.

7. In radio receiving apparatus, a detector tube having anode, cathode, and grid electrodes, a source of direct-current anode potential, a resistance between the negative terminal of said source and said cathode traversed by the audio-frequency and direct current components of the detector anode current, an input element connected at one terminal to the grid of said tube, a condenser offering small impedance to currents of radio frequency connected between the cathode of said tube and the other terminal of said input element, a direct current path from said other terminal to a point of said resistance removed from the cathode to effect biasing of said grid, and a translating device responsive to audio frequencies including said resistance in its input circuit.

8. In radio receiving apparatus, a detector

5 tube having anode, cathode, and grid electrodes, a source of direct-current anode potential, a resistance between the negative terminal of said source and said cathode traversed by the audio frequency and direct current components of the detector anode current, an input element connected at one terminal to the grid of said tube, a condenser offering small impedance to currents of radio frequency connected between the cathode of said tube and the other terminal of said input element, a direct current path from said other terminal to a point of said resistance removed from the cathode to effect biasing of said grid, a second resistance included in said path and cooperating with said condenser to prevent fluctuation of the grid potential at audio-frequency and to modify the biasing potential on the grid in accordance with the amplitude of the signal, and a translating device responsive to audio frequencies including said first resistance in its input circuit.

9. In radio receiving apparatus, a detector tube having anode, cathode, and grid electrodes, a source of direct-current anode potential, a resistance connected between the negative terminal of said source and said cathode and traversed by the audio frequency and direct current components of the detector anode current, an input element having a terminal connected to the grid of said tube, a condenser of low impedance to radio-frequency currents connecting another terminal of said element to the cathode of said tube, and a second resistance connecting said other terminal of said element to a point of said first resistance removed from cathode to effect negative biasing of the grid, said condenser and second resistance comprising a network for modifying the grid biasing potential and whose time constant is greater than the period of the lowest frequency of said audio frequency component of the anode current.

10. In radio receiving apparatus, a detector tube having anode, cathode, and grid electrodes, a source of direct current anode current, a resistance connected between the negative terminal of said source and said cathode and traversed by the audio frequency and direct current components of the detector anode current, a path in shunt to said resistance including a condenser and a second resistance in series, said condenser and second resistance comprising a network for varying the grid biasing potential in accordance with signal amplitude and whose time constant is greater than the period of the lowest frequency of said audio frequency component of the anode current, means for impressing modulated radio-frequency energy upon the input-circuit comprising an input element connected from the grid to a point in said shunt path between said condenser and said second resistance.

11. In radio receiving apparatus, a detector tube, a source of anode current, a resistance of substantial magnitude connected between the cathode of said tube and the negative terminal of said source and traversed by the audio-frequency and direct current components of the detector anode current, a condenser of low impedance to audio-frequencies connecting the grid of said tube to the cathode whereby the grid is of substantially the same audio-frequency potential as the cathode, a resistance connecting the grid of said tube to a point of said first resistance whereby the grid is negatively biased with respect to cathode by the direct current component of the detector anode current, said second named resistance and condenser cooperating to vary the grid-biasing potential in accordance with the amplitude of received signal energy, an audio amplifier tube, and connections of low impedance to audio frequencies from the grid and cathode of said amplifier tube to the cathode of said detector tube and the negative terminal of said source respectively, for impressing on the input electrodes of the amplifier tube an audio-frequency potential derived from the audio-frequency component of the detector anode current.

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