June 5, 1934.

G. L. BEERS

1,961,329

RADIORECEIVER

Filed June 20, 1931

2 Sheets-Sheet 1

Fig.1.

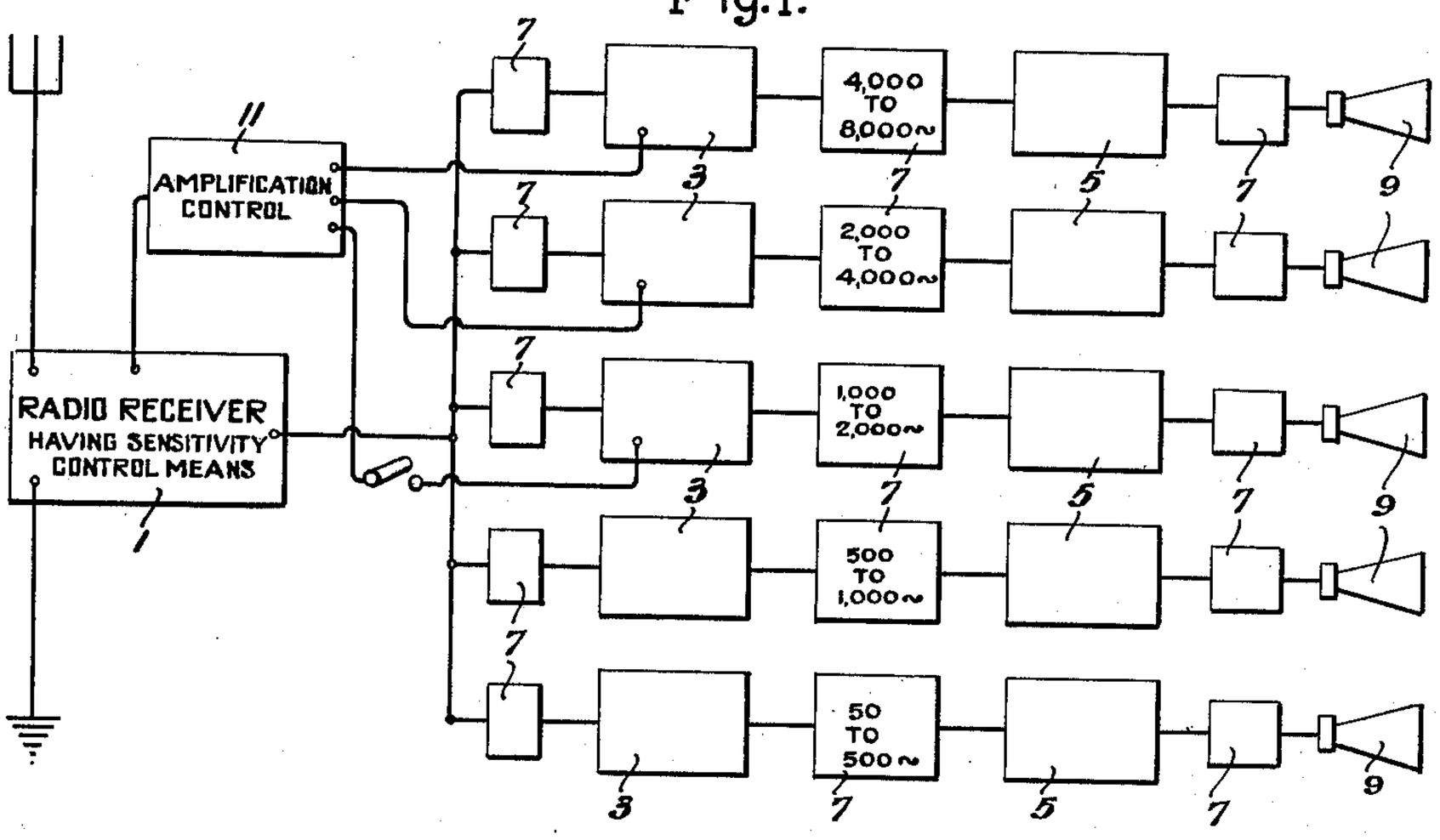

Fig.2.

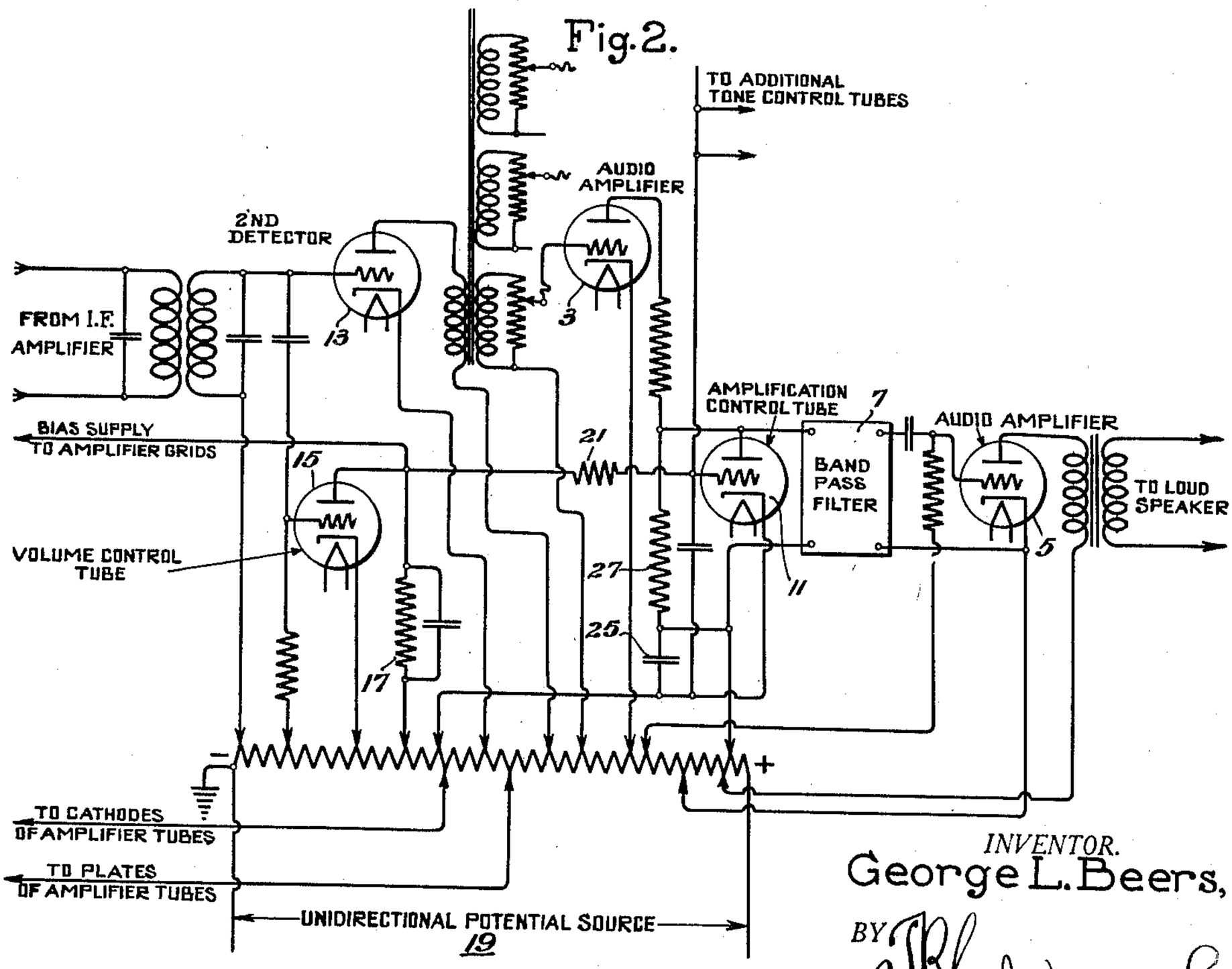

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Fig.3.

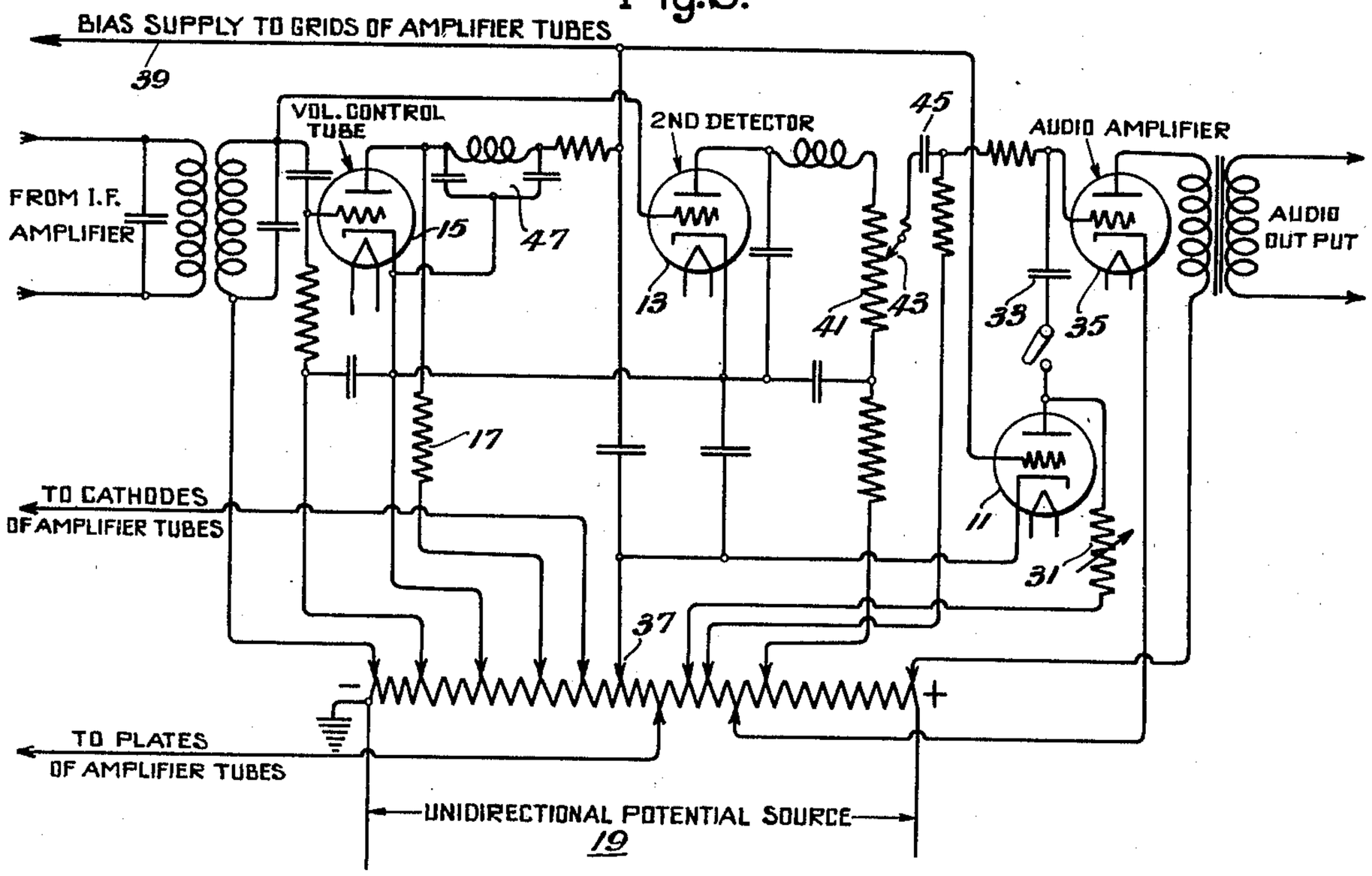
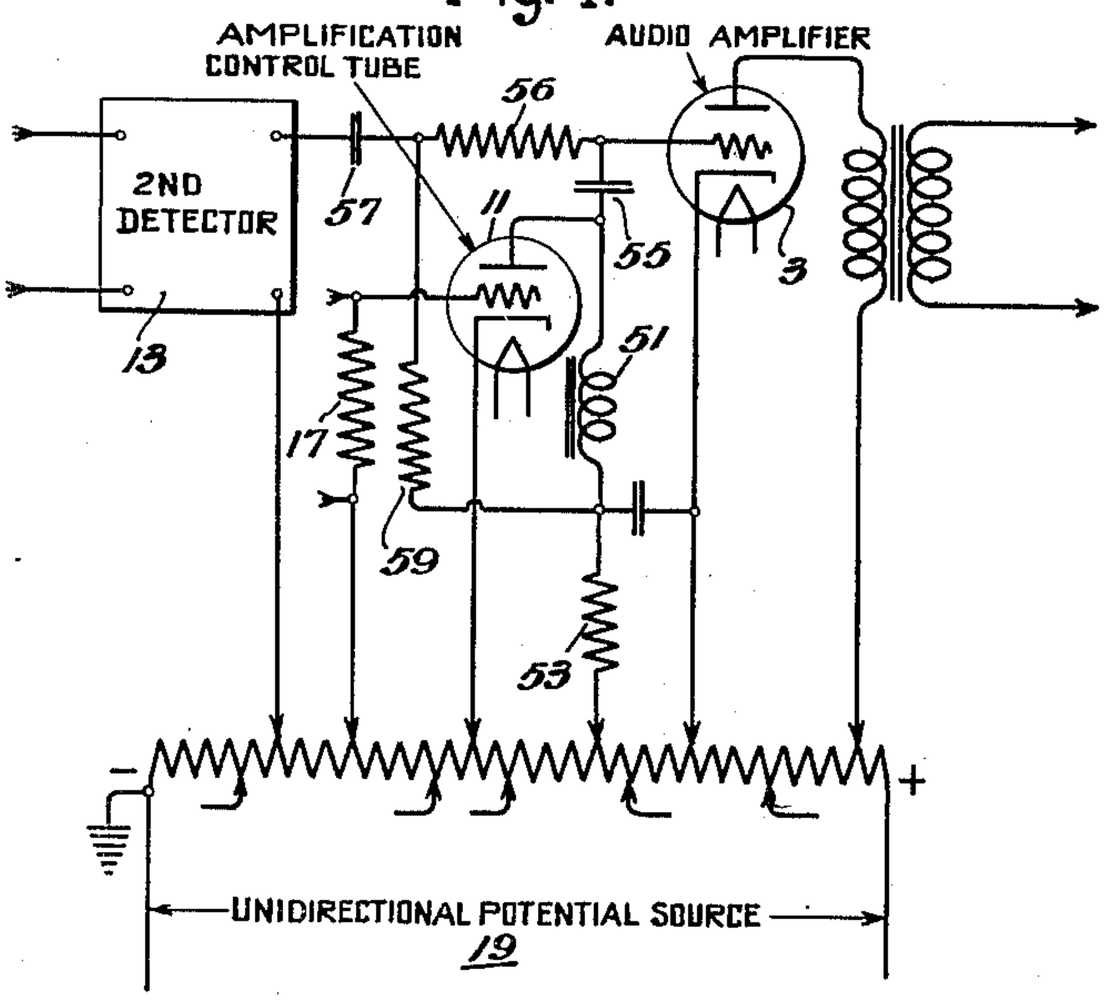


Fig.4.



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Patented June 5, 1934 1,961,329

UNITED STATES PATENT OFFICE

1,961,329

RADIORECEIVER

George Lisle Beers, Collingswood, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application June 20, 1931, Serial No. 545,704

29 Claims. (Cl. 250—20)

My invention relates to radio receivers and, more particularly, to tone control devices therefor.

When the sensitivity of a radio receiver is increased, for the purpose of receiving weak signals from distant stations, the background noise becomes objectionably loud. The noise is probably caused, in part, by atmospheric disturbances and, in part, by electron impact and other phenomena arising in the receiving apparatus itself. At any rate, irrespective of the origin of the background noise, it is largely comprised of frequencies quite high in the audio range, which frequencies may be eliminated from the ultimate sound output of the receiver without too seriously militating against intelligibility.

It is, accordingly, an object of my invention to provide a tone control for a radio receiver that shall minimize high audio frequency response concurrently with an increase in the sensitivity of the receiver.

Another object of my invention is to provide a tone control for a radia receiver that shall be automatic in action.

A still further object of my invention is to provide a tone control for a radio receiver, or the like that shall automatically respond only to relatively slow changes in the amplitude or average amplitude of incoming signals.

In practicing my invention, I find it expedient, though not absolutely necessary, to accomplish audio frequency amplification through the use of a plurality of amplifying channels fed from a master receiver, instead of using a single channel for the purpose of handling all audio frequencies. Each of the channels is, preferably, individually responsive to a different normal range of frequencies and the total range of all of the channels is such as to embrace all frequencies involved in sound reproduction. The amplifying channels and the necessary loudspeakers individual thereto, may correspond to successive octaves in the audio frequency spectrum, if desired, for a purpose which will be referred to again.

One or more of the channels devoted to the higher audio frequencies is provided with volume control means. The volume control means may take the form of any well known network or it may be constituted merely by a variable resistance device. Alternatively, the loudspeaker or speakers handling the high frequencies may be provided with volume control means, although, obviously, more power is required to control the loudspeakers themselves than if control is had in one or more of the preceding amplifier stages.

The exact point at which volume control of the high frequency channel is accomplished is relatively immaterial provided the control is automatic and is responsive to the amplitude of the incoming signal or, to state the matter somewhat differently, to the sensitivity of the receiver. The manner in which I provide for automatic actuation of the tone control device, however, is an important part of my invention.

In a preferred embodiment the incoming signal, after proper amplification at radio and/or intermediate frequency, is applied to the grid of a main volume control tube and the output current from the tube is used to actuate one or more secondary volume control devices. Specifically, in the embodiment of my invention under discussion, each secondary volume control device comprises a resistor or a choke-coil serially included in the output circuit of an amplifier tube, the effective value of the resistor being determined by the plate-impedance of a thermionic tube connected in shunt relation thereto.

In the said embodiment the plate impedance of the tube is a function of the total negative grid bias potential applied thereto, which bias is determined by the amplitude of the output current through the volume control tube and the circuit connections are such that the shunting action of the tube is accentuated when weak signals are being received.

My invention is also applicable to a radio receiver having only a single audio channel, in which event the tube and shunting resistor may be connected in series with a capacitor to constitute a controllable shunt for audio frequency currents at high frequencies.

The present invention may be regarded as an improvement over the invention disclosed in a co-pending application of Walter Van B. Roberts, Serial No. 445,937, filed April 21, 1930, entitled "Automatic tone control" and assigned to the same assignee as this application.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment, when read in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a complete

signal receiving system constructed according to my invention;

Fig. 2 is a diagrammatic view of a portion of the system shown in Fig. 1;

Fig. 3 is a diagrammatic view of a slightly different form of my invention, and

Fig. 4 is a diagrammatic view of an alternative embodiment of my invention.

Referring specifically to Fig. 1 of the drawings one embodiment of my invention includes a radio receiver 1, the output currents therefrom, at audio frequencies, are supplied to a plurality of audio-frequency amplification channels. Each channel may include a plurality of audio-frequency amplifiers 3 and 5 and suitable band-pass filters 7 to limit the channel to a definite frequency-range for which a loudspeaker 9, energized thereby, is particularly designed.

The radio receiver 1 may, if desired, be of the multi-stage type having automatic volume-control means and, preferably, it should be provided with means whereby its sensitivity to incoming signals may be controlled for the purpose of satisfactorily receiving signals from either local or distant stations.

By dividing the audio-frequency range into octaves and by using a single channel for each octave, the distortion occasioned by the production of harmonics in the various circuits handling audio frequency currents may be avoided and substantially perfect reproduction may be obtained. For practical purposes, however, in order to save expense, the range may be divided as indicated in the drawings, with excellent results.

It is also feasible to apply my invention to a system comprising only two audio channels. In such event I prefer to utilize a dynamic loudspeaker for the range from 50 to 2000 cycles, and a loudspeaker of the condenser type for frequencies above 2000 cycles.

In order that the objects of my invention may be accomplished I provide means whereby the high frequency response of the system, as a whole, is diminished when the incoming signal has an average amplitude lower than a predetermined value. For this purpose, I provide a signal-amplitude responsive device 11 which is so disposed as to control the gain in one or more of the channels allocated to high audio frequencies. If the incoming signal is weak, and the sensitivity of the receiver is, accordingly, increased, the gain in the controlled stages is correspondingly reduced to a point where the reproduced sound is substantially free from disagreeable background noise. Conversely, when the incoming signal is sufficiently strong to enable satisfactory reception with the sensitivity of the receiver reduced the gain in the controlled stages is permitted to return to normal, giving high fidelity.

There are, of course, many specific ways in which the control circuits, comprised in the system shown in Fig. 1, may be arranged. I prefer, however, to utilize a super-heterodyne radio receiver of the type provided with automatic volume-control devices and to connect the amplification-control for the audio channels as shown in detail in Fig. 2.

The super-heterodyne receiver comprises a plurality of radio frequency amplification stages, an oscillator, a first detector and a plurality of intermediate frequency amplification stages, none of which are illustrated since they are familiar to those skilled in the art. A manually operable sensitivity control device (not shown) may be included, if desired. Sensitivity-control devices, such as variable input-circuit resistors, bias-potential adjusting potentiometers and resistors and the like are also well known to radio engineers; they therefore need no explanation.

The receiver also includes a second detector tube 13 and a volume-control tube 15 across the input circuits of which are simultaneously impressed signal potentials derived from the intermediate frequency amplifier. The plate circuit of the volume-control tube includes a resistor 17, the voltage drop across which supplies to certain of the amplifier tubes a negative grid biasing potential in excess of the normal potential derived from a source 19 common to all of the tubes in the system.

The plate of the volume control tube is connected, through a resistor 21 to the grid of the amplification-control tube 11 the space-current path in which, in series with a condenser 25, effectively shunts a coupling-resistor 27 or a choke-coil included in the output circuit of the audio-frequency amplifier 3 energized from the second detector.

By applying a suitable negative bias to the grid of the volume-control tube, the space current flowing in the plate circuit resistor 17 may be so reduced that the bias supplied to the preceding amplifier tubes maintains the sensitivity of the system at the proper point for the reception of weak signals. Such signals, impressed on the input circuit of the volume-control tube cause substantially no space current to flow in the said tube and, consequently, the fixed bias on the amplification-control tube 11 is substantially that determined by the point on the common potential source 19 to which the cathode thereof is connected. The point in question is so chosen, therefore, that the fixed bias is such as to maintain the plate-impedance of the tube near the minimum value.

During the reception of weak signals, therefore, when the system is in the sensitive condition, the resistor 27, or the choke-coil, if one is used, is effectively by-passed, for audio frequencies, by the amplification-control tube and the condenser 25 connected between the cathode of the tube and the lower end of the resistor. The high frequencies, accordingly, are not passed on to the audio-frequency amplifier 5 and the quality of the reproduced sounds is not marred by their presence.

When strong signals are received the space current in the volume-control tube resistor 17 increases thus causing the bias applied to the grid of the amplification-control tube 11 to become more negative, whereby the plate impedance thereof increases. The shunting effect of the amplification control tube diminishes and, as a consequence, signals at high frequencies are passed on through the band-pass filter 7 and the audio frequency amplifier 5 to energize the loudspeaker 9 associated with the controlled channel. Concurrently with the decrease in the high frequency attenuation, the sensitivity of the system is reduced through the more negative bias supplied to the grids of the earlier amplifying tubes (not shown).

Instead of associating the amplification-control tube 11 with the output circuit of the amplifier tube 3, it also lies within the scope of my invention to dispose it at any other desirable point in the amplification channel. For example, as shown in Fig. 4 of the drawings, the tube 11 may be connected effectively in shunt to a choke-coil 51 which coil is serially included in a circuit, com-

prising a resistor 53 and a condenser 55, extending between the grid of the amplifier tube 3 and a point on the potential source 19. A connection, including a resistor 56 and a blocking condenser 57, extends from the plate of the second detector tube to the grid of the audio frequency amplifier 3 and a bias-supply circuit, including a resistor 59, is connected from a point intermediate the condenser 57 and the resistor 56 to a point between the choke-coil 51 and the resistor 53.

The normal, or no-signal bias on the grid of the amplifier tube 3, therefore, is partly determined by the voltage drop between the points on the potential source 19 to which the resistor 53 and the cathode of the tube, respectively, are connected.

When weak signals are received, the voltage drop across the resistor 17 does not change appreciably and the tube 11 has minimum plate-impedance thus by-passing the choke-coil 51 to reduce the input to the tube 3. At the same time, the space current in tube 11, flowing in the resistor 53, causes a voltage drop across the said resistor which, when added to the bias on tube 3 fixed by the grid and cathode connections to the source 19, reduces the gain in the tube sufficiently to prevent the channel from energizing the loudspeaker (not shown) associated therewith.

Conversely, when stronger signals give rise to increased current in the resistor 17, as hereinbefore explained, the plate-impedance of the tube 11 increases, thus reducing the current in the resistor 53. Diminished current in the resistor 53 results in the bias on the grid of the tube 3 becoming less negative, with the result that the gain therein increases simultaneously with the impression thereon of signal potentials from the second detector.

As heretofore stated, it is also feasible to apply my invention to a receiving system which includes only a single audio frequency amplification channel. Such modification of my invention is disclosed in Fig. 3 of the drawings wherein elements analogous to those shown in Fig. 2 are similarly designated.

Referring to Fig. 3, the radio receiver (not shown) preceding the portion of the system illustrated is of the superheterodyne type, the same as was referred to in connection with the description of Fig. 2. The volume control tube 15 and the second detector tube 13 are similarly interconnected for energization from the intermediate frequency amplifier and are similarly energized from the common unidirectional potential source 19.

The tone control tube 11, however, is disposed in a different position; it is connected in shunt relation to a resistor 31, or a choke-coil, which resistor or coil and a small capacitor 33 are connected across the input terminals of an audio-frequency amplifying tube 35. The condenser and the resistor or coil constitute a tone-control circuit, the electrical value of the resistor or coil being such that when the plate impedance of the tone-control tube is maximum, the effect of the condenser as a by-pass is negligible.

The bias potentials applied to the volume-control tube and the tone-control tube are so chosen that when no signals are being received, the plate impedance of the said tone control tube is minimum. When weak signals are received, the change in plate circuit in the volume-control tube is negligible and a negligible change occurs in the plate impedance of the tone control tube. Under such conditions, the by-pass condenser is effective to attenuate the higher audio frequencies and the sound reproduction is substantially free from background noise.

Conversely, when strong signals are received, the plate current in the volume-control tube increases causing a voltage drop across the resistor 17 included in the output circuit thereof, which drop, when applied to the grid of the tone control tube, renders it sufficiently negative to raise the plate impedance thereof to a value as great as, or greater than, that of the resistor 31 to which the tube is connected in shunt.

When receiving strong signals, therefore, the higher frequencies are not by-passed and the fidelity of reproduction is improved.

In case it is desired, an adjustment may be provided which will enable the user to predetermine the field-strength level at which the tone-control tube begins to operate. Such adjustment might be obtained through the use of a potentiometer to vary the fixed bias on the tone control tube, or by making the connection 37 of the cathode of the tube to the potential source adjustable.

Inasmuch as the preceding tubes of the system are automatically controlled as to their sensitivity by reason of a connection 39 extending to the plate of the volume control tube, the output from the second detector tube increases very little in response to increased signal carrier amplitude. In order, therefore, to adjust the sound output from the system to a pleasing level, I find it expedient to make the connection between the second detector and the audio-frequency amplifier adjustable. The adjustability may be easily secured by including a resistor 41 in the plate circuit on the second detector tube with which a variable contact element 43, connected to the grid of the audio frequency amplifier through a blocking condenser 45, is associated.

In order that the tone-control tube shall be precluded from responding to minor changes in signal amplitude, such as are caused by crescendo or diminuendo musical passages, it is advisable to include a filter 47 in the output circuit of the volume control tube, which filter has a time constant of several seconds or more.

It will, accordingly, be apparent from a consideration of the foregoing description of several embodiments of my invention that I have provided an improved signal receiving system whereby signals from distant stations may be received with greater clarity than through the use of conventional radio receiving apparatus. It will further be evident that, since my improved system is automatic in operation, the advantages accruing therefrom are not dependent upon the skill of the operator.

It should be clearly understood, however, that in certain cases it may be desirable to utilize manually operable means, instead of the automatic means herein shown and described, for the purpose of simultaneously controlling the frequency-response of the system and the sensitivity thereof. In such event, the tube 11 may be omitted and the impedance device to which it is connected in shunt may, instead, be made variable and the sensitivity-control means in the receiver may be mechanically coupled to the said device for actuation through a single dial, knob or the like.

Although I have illustrated and described several alternative forms of my invention, many other modifications will be apparent to those skilled in the art to which it pertains. My invention, therefore, it not to be restricted except insofar as is

necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. The method of operating signal receiving apparatus of the type comprising audio frequency responsive means which includes receiving a super-audible signal and utilizing said signal for controlling the range of frequencies to which said first named means is effectively responsive.

2. The method as set forth in claim 1 wherein the range of effective response is a function of the amplitude of the incoming signal.

3. The method as set forth in claim 1 wherein the effective high-frequency response is caused to decrease with a decrease in the amplitude of an incoming signal.

4. The method as set forth in claim 1 wherein the effective high-frequency response is caused to increase with an increase in the amplitude of an incoming signal.

5. The method of operating electric signal amplifying systems which includes varying the sensitivity of the system to incoming high frequency signals and concurrently controlling electronically an audio frequency response characteristic of the said system automatically in response to variations in the average amplitude of such high frequency signals.

6. The method as set forth in claim 1 wherein, as the sensitivity of the system is increased the high frequency response is decreased.

7. The method as set forth in claim 1 wherein, as the sensitivity of the system is decreased, the high-frequency response in increased.

8. In an amplifying system, means for controlling the audio-frequency response characteristic thereof, and means responsive to super-audible signals for automatically actuating said control means.

9. In a signal receiving system, a plurality of amplifying devices responsive, respectively, to high and low audio audio-frequency signals, and means responsive to super-audible signals for controlling the effective response of at least one amplifying device allocated to high audio frequencies.

10. In a signal receiving system, means for amplifying currents at audio-frequencies, means for controlling the range of frequencies effectively amplified thereby, and super-audible signal-responsive means for automatically adjusting said controlling means.

11. In a radio signal receiving system, the combination with a signal amplifier, a detector, and an audio frequency amplifier, of means providing a high audio frequency amplifying channel in said last named amplifier, means connected with said channel for attenuating audio frequency signals within a certain high range of such frequencies, an electronic amplifier device connected with said attenuating means to control its connection with said signal channel, said device having an anode and cathode in said connection, and having a control grid, and means responsive to signals transmitted through said amplifier and independent of signals transmitted through said audio frequency amplifier for controlling potentials applied to said grid.

12. In a radio signal receiving system the combination with a signal amplifier, a detector, and an audio frequency amplifier, of means providing a high audio frequency amplifying channel in said last named amplifier, means connected with said channel for attenuating audio frequency signals within a certain high range of such frequencies, impedance means connected with said attenuating means to limit the flow of current therethrough, an electronic amplifier device connected in parallel with said impedance means, said thermionic device having a control grid, and means responsive to signals transmitted through said signal amplifier and independent of signals transmitted through said audio frequency amplifier for controlling potentials applied to said grid.

13. In a radio signal receiving system including a signal amplifier, a detector, and an audio frequency amplifier, the combination of means providing a high audio frequency amplifying channel in said last named amplifier, means connected in shunt to said channel for attenuating audio frequency signals within a certain high range of such frequencies, impedance means connected in series with said attenuating means to limit the flow of current therethrough, an electronic amplifier device having its anode and cathode connected with said impedance means, whereby said last named means and said device are connected in parallel, said device having a control grid, and means responsive to signals transmitted through said signal amplifier and independent of signals transmitted through said audio frequency amplifier for controlling potentials applied to said grid.

14. In a signal receiving system having automatic volume control means, the combination of an audio frequency amplifier providing an amplifying channel for audio frequency signals in a predetermined high audio frequency range, means connected in said audio frequency amplifying channel for attenuating at least a portion of said audio frequency range, a circuit impedance device connected in series with said attenuating means for controlling its effect in said channel, and an electronic amplification control device having an anode circuit connected in shunt with said impedance device and having a control grid connected with said automatic volume control means.

15. The method of operating signal receiving apparatus of the type comprising audio frequency amplifying means which includes receiving a super-audible signal and utilizing said signal for effecting a control of the audio frequency response characteristic of said first named means.

16. In a radio signal receiving system, the combination of an automatic volume control means responsive to high frequency signals, audio frequency signal attenuating means, and an electronic tube connected between the automatic volume control means and the signal attenuating means as a control device to effect a control of the audio frequency signal attenuation in response to operation of the automatic volume control means.

17. In a radio signal receiving system, the combination with a high frequency signal receiving channel and an audio frequency signal channel, of an electronic volume control device having an input circuit connected with the high frequency signal receiving channel and having an output circuit, an electronic control device having a control electrode connected with said output circuit, means connected with the audio frequency signal channel for attenuating audio frequency signals within a certain higher range thereof, said control device being interposed in said connection whereby the attenuation of said signals is controlled in response to the average amplitude of signals in the high frequency signal receiving channel.

18. In a radio signal receiving system, the com-

bination of an automatic volume control means responsive to high frequency signals, audio frequency signal attenuating means, and an electronic amplifier device having a control electrode connected with the automatic volume control means to receive controlling potentials therefrom and having output electrodes connected in circuit with the signal attenuating means, thereby to effect a control of the audio frequency signal attenuation in response to operation of the automatic volume control means.

19. The method of operating a radio receiver which consists in collecting signal energy, amplifying the collected energy, detecting the amplified energy, controlling the amplification of the collected energy before detection, in accordance with received signal field strength to maintain a predetermined amplification level, and variably attenuating the detected signal energy within a predetermined higher audio frequency range, in accordance with variations in the received signal field strength.

20. The method of operating a radio receiver which consists in collecting signal energy, amplifying the collected energy, detecting the amplified energy, automatically controlling the amplification of the collected energy inversely with received signal field strength to maintain a uniform amplification level, and attenuating the high frequency detected signal energy when the received signal field strength decreases below the background noise level.

21. The method of operating a radio receiver which consists in collecting signal energy, amplifying the collected energy, detecting the amplified energy, controlling the amplification of the collected energy inversely with received signal field strength to maintain a uniform amplification level, and automatically attenuating the high audio frequency detected signal energy when the received signal field strength falls below the background noise level.

22. A method of suppressing background noises in a radio receiver which consists in collecting signal energy, amplifying such energy, detecting the amplified energy, maintaining the amplification of the collected energy at a uniform level during reception, and suppressing the relatively high frequency components of the detected signal energy during such periods of reception when the signal field strength decreases below the background noise level.

23. In a radio signal receiving system, the combination of signal receiving means, audio frequency signal attenuating means, and an electronic control device connected between said first and second named means to effect a control of the audio frequency signal attenuation in response to changes in the amplitude of the received signals.

24. In a radio receiver, audio frequency amplifying means adapted to cover a wide range of frequencies, super-audible signal responsive means for automatically controlling the amplification of currents at frequencies lying in the upper end of the range, and manually operable means for adjusting the measure of automatic control.

25. In a radio receiving system, means for receiving signals within a predetermined frequency range, means for amplifying signals within a different frequency range, and control means for varying the frequency responsive characteristic of said last named means in accordance with variations in the amplitude of signals received by said first named means.

26. In an electric signal amplifying system, means for varying the frequency response characteristic of one portion of said system, and means responsive to signals at a differing frequency outside the frequency range of signals transmitted by said first named portion for controlling said first named means.

27. In a radio receiver, sensitivity-control means, audio frequency fidelity-control means, and means responsive to changes in strength of incoming signals for automatically actuating each of said control means.

28. In a radio receiver, sensitivity-control means, audio frequency fidelity-control means, and means responsive to changes in strength of incoming signals for automatically and concurrently actuating each of said control means.

29. In combination, a radio frequency amplifier, a detector, means providing signal input and output circuits for the detector, means associated with the detector input circuit for controlling the gain of the amplifier, and additional means, including a voltage variable reactance path having a low impedance to audio frequency currents, responsive to the gain control means for automatically attenuating high audio frequency signals in the detector output circuit.

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