April 9, 1940. D. G. BURNSIDE 2,196,248

COMBINED AMPLIFIER-RECTIFIER CIRCUITS

Original Filed Dec. 16, 1933 2 Sheets-Sheet 1

Fig. 1

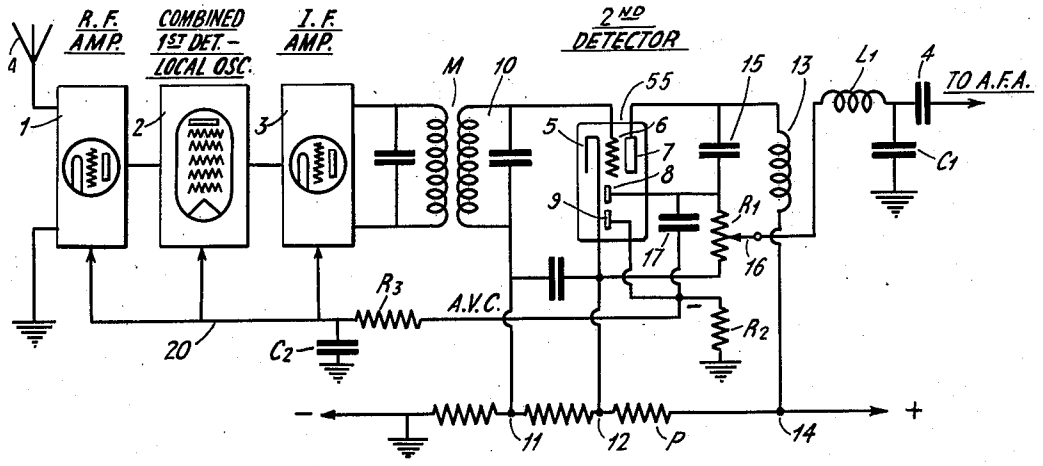


Fig. 2

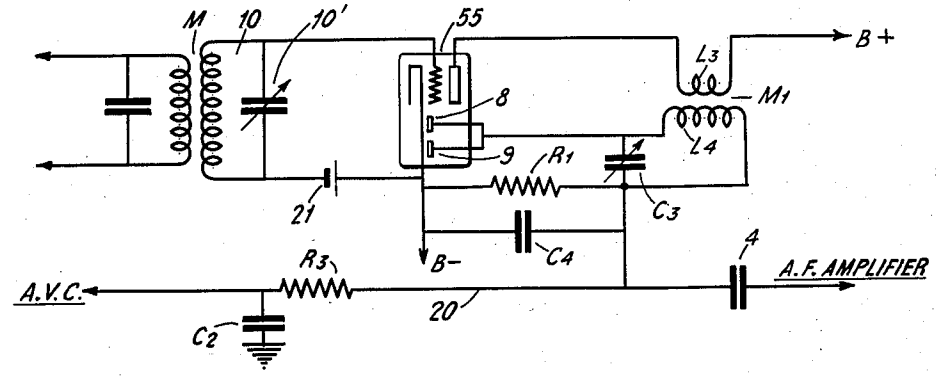
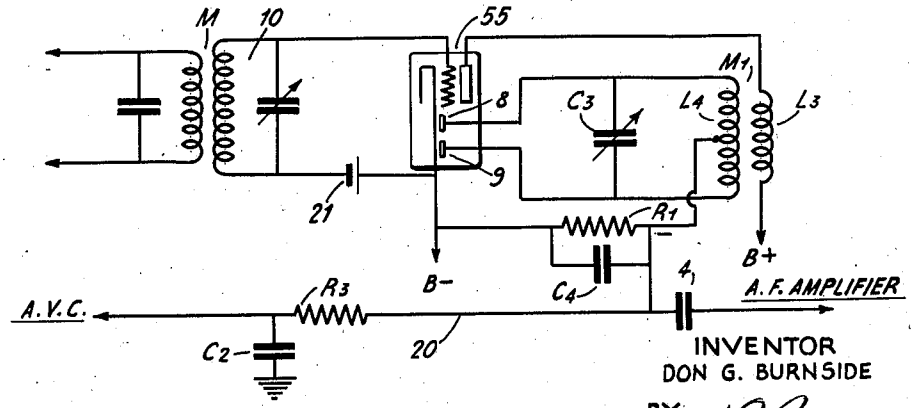


Fig. 3



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Fig. 5

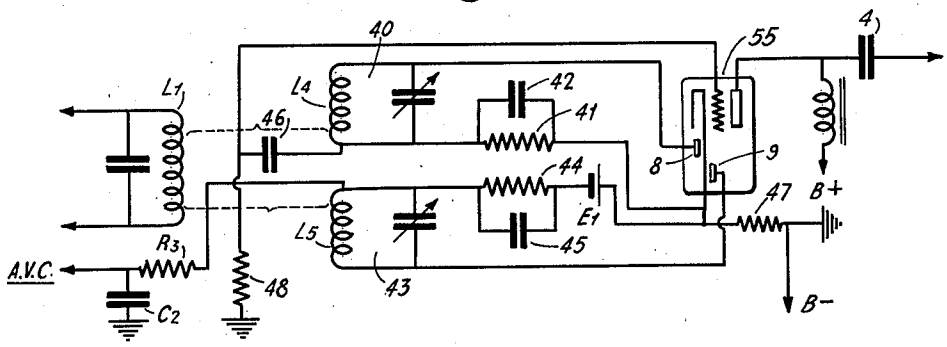


Fig. 6

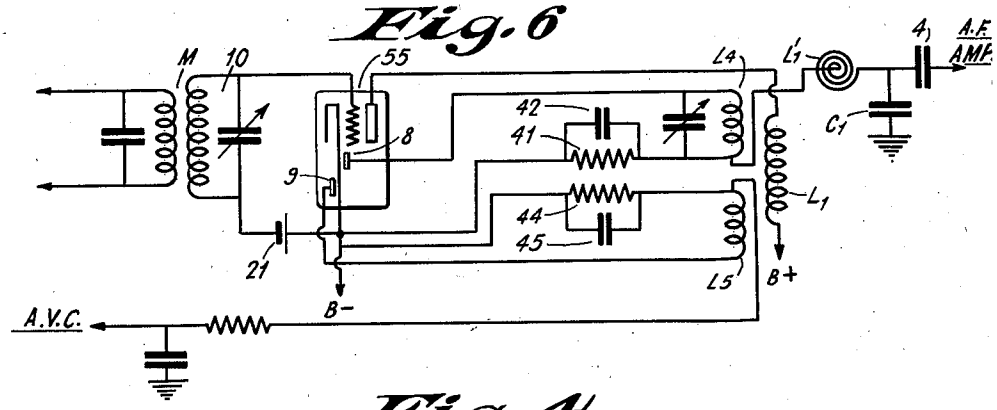
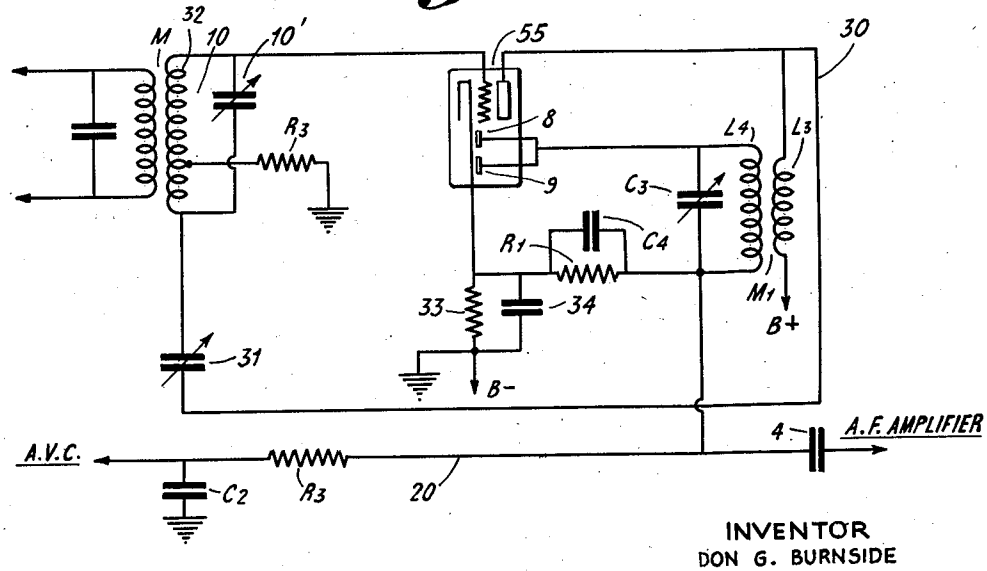


Fig. 4



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UNITED STATES PATENT OFFICE

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COMBINED AMPLIFIER-RECTIFIER CIRCUITS

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Application December 16, 1933, Serial No. 702,675
Renewed May 7, 1938

7 Claims. (Cl. 250—20)

My present invention relates to improvements in combined radio frequency amplifier and rectifier circuits which utilize tubes of the duplex diode triode type.

In my application Serial No. 644,149, filed November 25, 1932, Patent No. 2,048,100, July 21, 1936, there have been disclosed various circuits for employing a multiple duty tube, known as a 55 tube. In one of these circuits the triode section of the multi-function tube has been shown utilized as a high frequency amplifier, the amplified high frequency energy in the anode circuit of the triode section being impressed upon at least one of the diode sections of the tube for rectification of the amplified energy. The audio frequency component of the rectified energy is utilized for subsequent audio amplification, while the direct current component of the rectified energy is employed for automatic volume control of one or more preceding high frequency stages.

In the present application there are disclosed additional circuit arrangements for utilizing a tube of the 55 type, and it may be stated that it is one of the main objects of this invention to employ a multiple duty tube for simultaneous radio frequency amplification, diode rectification for automatic volume control, diode detection for audio frequency amplification.

Another important object of the invention is to provide in a multiple duty tube circuit which performs radio frequency amplification prior to diode detection, an arrangement for balancing out the effect of undesirable oscillations which may arise by virtue of inherent capacity couplings existing in the radio frequency amplifier section of the multiple duty tube.

Still other objects of the invention are to improve generally combined detector-automatic volume control-radio frequency amplifier stages, and to particularly provide receivers employing such stages which are not only reliable in operation, but economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 diagrammatically shows a superheterodyne receiver employing a multi-function tube embodying one form of the present invention,

Fig. 2 and Fig. 3 each show different modifications of the invention,

Figs. 4, 5 and 6 show additional modifications of the invention.

Referring now to the accompanying drawings, wherein like reference characters in the different figures designate similar circuit elements, Fig. 1 diagrammatically shows a receiver of the superheterodyne type, wherein the second detector stage includes a circuit and tube combination employing the arrangement described above in connection with my co-pending application. Thus in Fig. 1 there is shown preceding the tube 55 the conventional superheterodyne receiver stages. As is well known in the art such a receiver usually embodies a signal collector, such as the usual grounded antenna circuit A, a tunable radio frequency amplifier 1, an intermediate frequency amplifier network 3, and a frequency changer network 2 connected between the networks 1 and 3.

The network 2 may embody separate local oscillator and first detector stages, or it may be of the combined first detector-local oscillator type as conventionally shown in Fig. 1. In the latter case it is preferred to have the tube used in network 2 of the pentagrid converter type, or as better known of the 2A7 type. The output of the intermediate frequency amplifier is impressed upon the second detector through a transformer M whose primary and secondary windings are tuned to the operating intermediate frequency, and the audio frequency output of the second detector is supplied to an audio frequency amplifier, not shown, through a coupling condenser 4, the audio frequency amplifier output being reproduced in any well known manner.

The tube 55 includes a plurality of electrodes arranged in the manner described in application Serial No. 622,140, filed July 12, 1932 by T. M. Shrader, Patent No. 2,058,834, October 27, 1936. Such a tube includes a pair of diode sections and a triode section, the cathode 5, preferably of the indirectly heated type, being common to the cold electrodes 6, 7, 8 and 9 of the tube. This has been diagrammatically represented in Fig. 1, as well as the other figures, and it is to be clearly understood that the diagrammatic representation signifies the fact that the diode anodes 8 and 9 are positioned outside the electron stream to the grid 6 and anode 7. In actual construction, and as shown in the aforesaid Shrader application, the diode anodes 8 and 9

are disposed adjacent a projecting end of the cathode sleeve 5, and are electrically independent of each other and of the triode section.

The arrangement shown in Fig. 1 has the triode section of tube 55 functioning as an amplifier of the high frequency energy impressed on the input circuit 10. The grid 6 and cathode 5 are coupled to the tuned circuit 10, while the anode circuit is reactively coupled to the diode anodes 8 and 9.

The operating direct current potentials for the electrodes of the triode section of tube 55 are derived from a bleeder resistor P, the negative side of the resistor being at ground potential, while the positive side is connected to the positive terminal of the power supply system. It is to be clearly understood that any well known form of power supply source, whether of alternating current or direct current origin, may be employed to provide a direct current through the bleeder resistor P. The grid 6 is connected to a point on resistor P, which point is numbered 11, the cathode 5 being connected to a point 12 which is at a higher positve potential, while the anode 7 is connected to the still more positive point 14 through a radio frequency choke coil 13.

The anode 8 is coupled to the plate 7 by means of capacitor 15. When a modulated alternating voltage is amplified by the triode section of tube 55, the alternating current voltage on the plate 7 is impressed on diode anode 8 through condenser 15. Current flows to anode 8 during each positive half cycle, and this current also flows through the load resistor R_1 which is arranged in series between the cathode 5 and the anode 8. An adjustable tap 16 is arranged to slide over the resistor R_1 so that a manual volume control device is provided. The potential drop across resistor R_1, which varies at the frequency of modulation of the received carrier, is transmitted to the grid of the following audio frequency amplifier through the coupling condenser 4. A radio frequency filter L_1—C_1 serves to remove any radio frequency voltage from the transmission line to the audio frequency amplifier.

The diode anode 9 also receives radio frequency signal voltage from the plate 7, and this is accomplished by coupling the anode to the diode anode 8 through the coupling condenser 17. Of course, the anode 9 could be coupled directly to the plate 7 through a capacitor.

A load resistor R_2 is arranged in series between the diode anode 9 and the cathode 5, and the direct component of the voltage developed across this load resistor is transmitted to the grids of any of the radio frequency tubes for automatic volume control purposes. In Fig. 1 the automatic volume control network is arranged between the negative side of resistor R_2 and the grid circuits of the networks 1, 2 and 3, a filter R_3—C_2 being disposed in the automatic volume control lead 20 to suppress audio frequency ripples. Delay action for the automatic volume control function is provided by the proper choice of the point 12 on resistor P. The voltage between the ground side of resistor P and point 12 is the delay bias, and the voltage between points 11 and 12 is the negative bias for grid 6, the potential for the plate 7 being developed between the positive side of resistor P and the point 12. The condenser 17 should be as low in capacitance as is consistent with good rectification efficiency in order to keep distortion at a minimum.

To avoid restricting the use of the diode anodes 8 and 9 operating together, or as independent rectifiers, to a method of supplying alternating voltage to them through a capacitor, there is shown in Fig. 2 a transformer coupling arrangement which can be used when rectification is arranged to occur in the diode circuit of tube 55. In Fig. 2 is shown a simple half wave arrangement wherein the radio frequency voltage across the winding L_3 induces a voltage in the secondary winding L_4 of the coupling transformer M_1. The winding L_4 is tuned to the incoming frequency by the variable condenser C_3 which is connected in shunt across the winding L_4. The resistor R_1 is the load resistor for the diode rectifier circuit, and is by-passed by the condenser C_4, the latter being of such size that it has low impedance to radio frequencies but high impedance to audio frequencies. The anodes 8 and 9 are strapped together and connected to one side of the variable condenser C_3, while the negative side of resistor R_1 has connected to it the automatic volume control lead 20, as well as the audio frequency coupling condenser 4.

The tuned circuit 10 may include a variable tuning condenser 10' if the condenser C_3 is variable, and if the receiver is of the tuned radio frequency type. Of course, where the receiver is of the superheterodyne type the condensers 10' and C_3 are fixed to tune their respective circuits to the operating intermediate frequency. It will thus be seen that in Fig. 2 the triode section of tube 55 functions as a radio frequency amplifier and the diode section serves as a half wave detector and automatic volume control rectifier.

In Fig. 3 is shown the circuit arrangement of Fig. 2 employed in a full wave rectification arrangement. It will be noted that in this case the transformer M_1 is used as the coupling means between the plate of tube 55 and the diode anodes 8 and 9. The load resistor R_1, shunted by the by-pass condenser C_4, is arranged in series between each diode anode and the cathode of tube 55. The audio frequency coupling condenser 4, and the automatic volume control lead 20, are both connected to the negative side of the load resistor R_1.

In connection with the arrangement shown in Figs. 2 and 3 feed back through the grid to plate capacity of tube 55 must be taken into account, particularly when the plate load is inductive. A method by which the effect of the inherent grid to plate capacity may be balanced out and another undesirable condition, that of parisitic oscillations, eliminated is by means of a modified form of the Rice circuit.

The circuit arrangement in Fig. 4 is similar to that shown in Fig. 2. The signal voltage on the grid of tube 55 is amplified and impressed on the diode anodes 8 and 9 by the coupling transformer M_1. To balance out the effect of the inherent grid to plate capacity in tube 55, there is employed a neutralizing connection 30 which includes an adjustable capacitor 31.

The neutralizing path is connected between the anode side of coil L_3 and the low alternating current potential side of the tuned input circuit 10. The secondary winding of transformer M is not center tapped, but is tapped below center to a degree required by voltage gain and balancing voltage on the grid. Balancing out of the grid to plate capacity effect is accomplished by the lower section of the input coil 32 inducing in the upper section thereof, and hence to the grid, a voltage equal, but of opposite phase, to that on the plate. The advantage of moving the tap on coil 32 down from the center

is that a larger portion of the voltage in the coil 32 is put on the grid than can be had by center tapping.

Parasitics can be eliminated, or at least rendered harmless, by grounding the tap on coil 32 through resistor R_3 having a magnitude of the order of 100 ohms for a circuit operating over the broadcast band of frequencies. It will also be noted that the negative bias for the grid of tube 55 is obtained by means of the selfbias resistor 33 which is arranged in the cathode lead of the tube 55, this resistor being by-passed by a condenser 34 for radio frequency currents.

In Fig. 5 there is shown a circuit arrangement wherein the signal voltage is applied to the diode anodes 8 and 9 operating as independent rectifiers, one of the diode rectifiers feeding audio voltage to the grid circuit of tube 55. The diode anode 8 is connected to the cathode through a path which includes in series the tuned input circuit 40 and the load resistor 41, the latter being shunted by the radio frequency by-pass condenser 42. The diode anode 9 is connected to the cathode through a path which includes in series the tuned input circuit 43, the load resistor 44, shunted by radio frequency by-pass condenser 45, and the bias source E_1. The coils L_4 and L_5 are excited by the primary coil L_1.

A tuning condenser for each secondary winding L_4 and L_5 is shown, but since these two windings are necessarily coupled together they have fairly close coupling, and therefore a single tuning condenser to tune one of the circuits 40 and 43 would probably be effective in tuning the other. The delay bias E_1 is used to retard the development of the automatic volume control voltage until a signal peak voltage that exceeds E_1 is built up across the winding L_5. The automatic volume control voltage, freed of high and low frequency variations by the filter R_3—C_2, is fed to the grids of the tubes to be controlled. The diode circuit which includes the anode 8 develops across resistor 41 an audio frequency component which is passed on to the control grid of tube 55 through a capacitor 46. Since the resistor 41 is on the cathode side of coil L_4, the condenser 42, in addition to allowing but little loss of radio frequency voltage across resistor 41 for efficiency in rectification, prevents all but a small part of the radio frequency voltage from being impressed on the grid, thus tending to avoid grid overloading and possible plate detection.

Bias for the grid of tube 55 may be provided by a selfbias arrangement including resistors 47 and 48 in series between the grid and cathode of tube 55, or diode biasing or fixed bias from a bleeder circuit or battery may be used.

In Fig. 6 is shown another transformer coupled arrangement which is similar in form to that of Fig. 5, but wherein the triode section of the tube is used to amplify the signal voltage, and wherein the rectification occurs in the diode circuits of the tube. In this arrangement the diode circuit including the anode 8 develops across load resistor 41 the audio frequency component which is impressed upon a subsequent audio frequency amplifier. The diode circuit including anode 9 develops across the load resistor 44 a direct current voltage for regulating the gain of preceding stages.

The effect of grid to plate capacity may be balanced out as indicated in Fig. 4. The input circuits of the two diodes are shown tuned by a single variable condenser, and this single condenser is adapted to tune both diode circuits because of the relatively close coupling between coils L_4 and L_5. Rectification occurs when the positive half of each cycle is impressed on the diode anodes. It is, of course, possible to use either diode circuit for demodulation and the other for automatic volume control.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular circuits shown and described, but that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. The combination with a tube comprising an envelope enclosing at least a cathode, grid and plate, and a rectifier having two anodes connected together, an oscillatory circuit connected between said grid and said cathode, means for impressing high frequency signal currents on said oscillatory circuit whereby the said tube is adapted to amplify the same, a path having a low impedance to the amplified output of said tube connected between said plate and the connected anodes, an impedance connected between one side of said path and said cathode, means adapted to supply the audio potential drop across said impedance to an amplifier, and an automatic volume control path connected to the low potential side of said impedance, a path for neutralizing the effect of the inherent capacity between the grid and plate, said path being connected between the plate and said oscillatory circuit.

2. The combination with a tube comprising an envelope enclosing at least a cathode, grid and plate, and a rectifier having two anodes connected together, an oscillatory circuit connected between said grid and said cathode, means for impressing high frequency signal currents on said oscillatory circuit whereby the said tube is adapted to amplify the same, a path having a low impedance to the amplified output of said tube connected between said plate and the connected anodes, an impedance connected between one side of said path and said cathode, means adapted to supply the audio potential drop across said impedance to an amplifier, and an automatic volume control path connected to the low potential side of said impedance, a resistor connected to an intermediate tap on the coil of said oscillatory circuit, and a neutralizing connection including a condenser between the plate of said tube and said oscillatory circuit.

3. The combination with a tube including an amplifier section comprising at least a grid, cathode and output electrode and a diode section, a tuned circuit connected between the grid and cathode of the amplifier section, means for impressing signal currents on the tuned circuit whereby said amplifier section is adapted to amplify the signal currents, a path of low impedance to amplified signal currents connected between the said output electrode and said diode section, an automatic volume control path connected to the negative side of a load resistor in the diode section circuit, a connection of low impedance to the audio component of the voltage developed across said resistor connected to a point on the latter and means for balancing out the effect of inherent grid to output electrode capacity in said amplifier section.

4. The combination with a tube comprising an envelope enclosing an amplifier section compris-

ing at least a cathode, grid and plate, and a rectifier section having two anodes connected together, an oscillatory circuit connected between said grid and said cathode, means for impressing high frequency signal currents on said oscillatory circuit whereby the amplifier section is adapted to amplify the same, a path having a low impedance to the amplified output of said amplifier section connected between said plate and the connected anodes, an impedance connected between one side of said path and said cathode, means adapted to supply the audio potential drop across said impedance to an amplifier, and an automatic volume control path connected to the low potential side of said impedance for utilizing the direct current voltage developed thereacross.

5. In a multi-function signal receiving system comprising an electron discharge tube having a cathode, a plate, at least one grid disposed in the electron stream between the cathode and plate, and at least two auxiliary anodes disposed adjacent the cathode outside said stream, a radio frequency signal input circuit connected between the grid and cathode, a radio frequency signal coupling path between the said plate and said anodes, circuit connections between the anodes and said cathode to provide rectification of the radio frequency signals impressed on the anodes, and at least two additional circuit connections to said rectification connections for utilizing the rectified signals, one of said additional connections deriving the direct current voltage component from said rectified currents, and the other additional connections deriving the audio voltage component from the rectified currents.

6. The combination with a tube comprising an amplifier section and a pair of diode sections, the amplifier section including at least a grid, cathode and plate, a tuned circuit connected between the grid and cathode of the amplifier section, means for impressing signal currents on the tuned circuit whereby said amplifier section functions as a signal current amplifier, a signal current connection between the plate circuit of said amplifier section and one of said diode sections, a resistor in said one diode section for developing an audio frequency voltage component from rectified signal currents, a path of low impedance to said component connected to said resistor, a resistor in the second diode section for developing a direct current voltage from rectified signal currents, and an automatic volume control connection to the negative side of said last resistor.

7. The combination with a tube comprising an amplifier section and a pair of diode sections, the amplifier section including at least a grid, cathode and plate, a tuned circuit connected between the grid and cathode of the amplifier section, means for impressing signal currents on the tuned circuit whereby said amplifier section functions as a signal current amplifier, a signal current connection between the plate circuit of said amplifier section and one of said diode sections, a resistor in said one diode section for developing an audio frequency voltage component from rectified signal currents, a path of low impedance to said component connected to said resistor, a resistor in the second diode section for developing a direct current voltage from rectified signal currents, and an automatic volume control connection to the negative side of said last resistor, an adjustable connection between the first mentioned resistor and the audio frequency path.

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