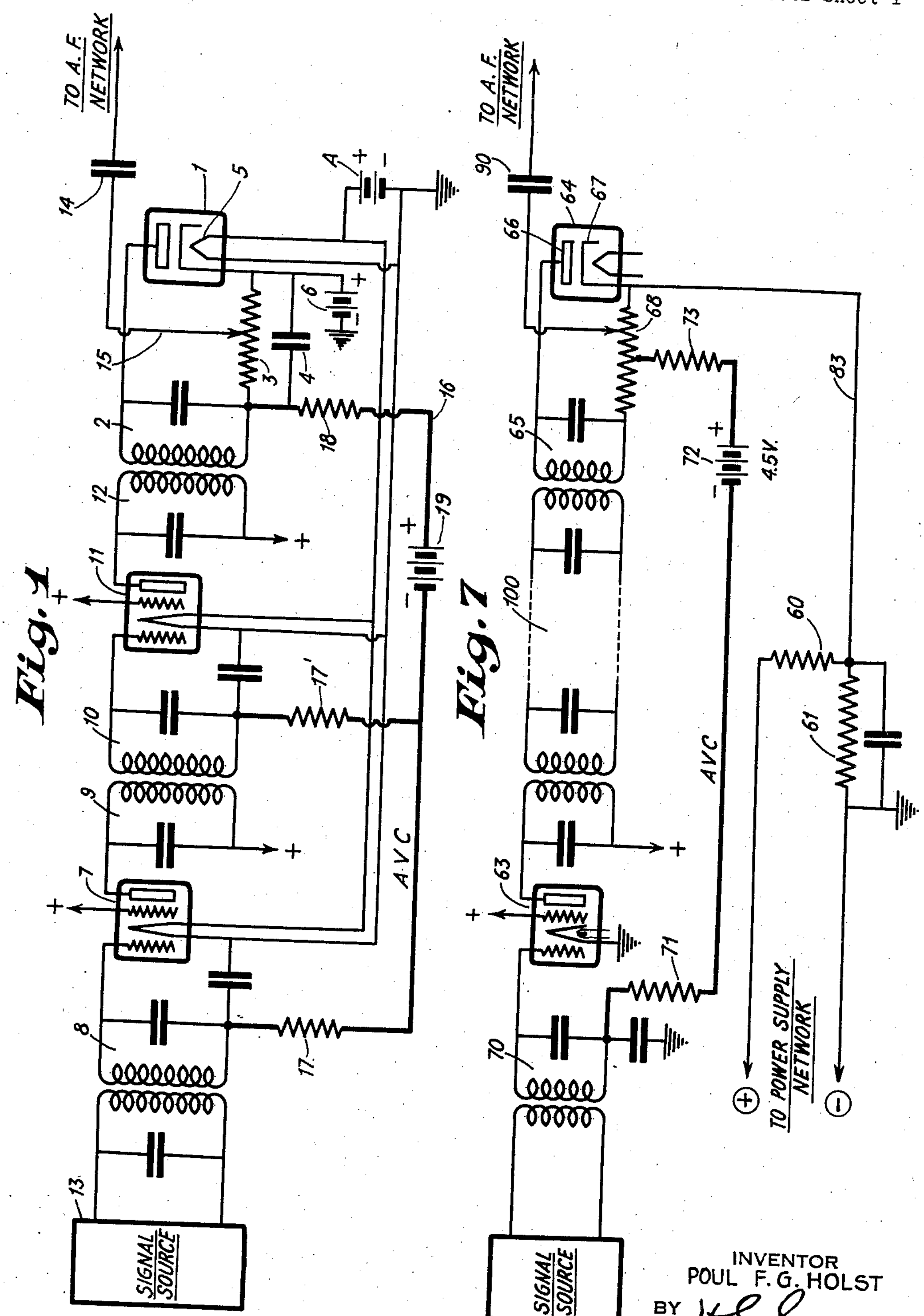
AUTOMATIC VOLUME CONTROL CIRCUITS

Filed Sept. 20, 1935

3 Sheets-Sheet 1



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2,144,920

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3 Sheets-Sheet 2

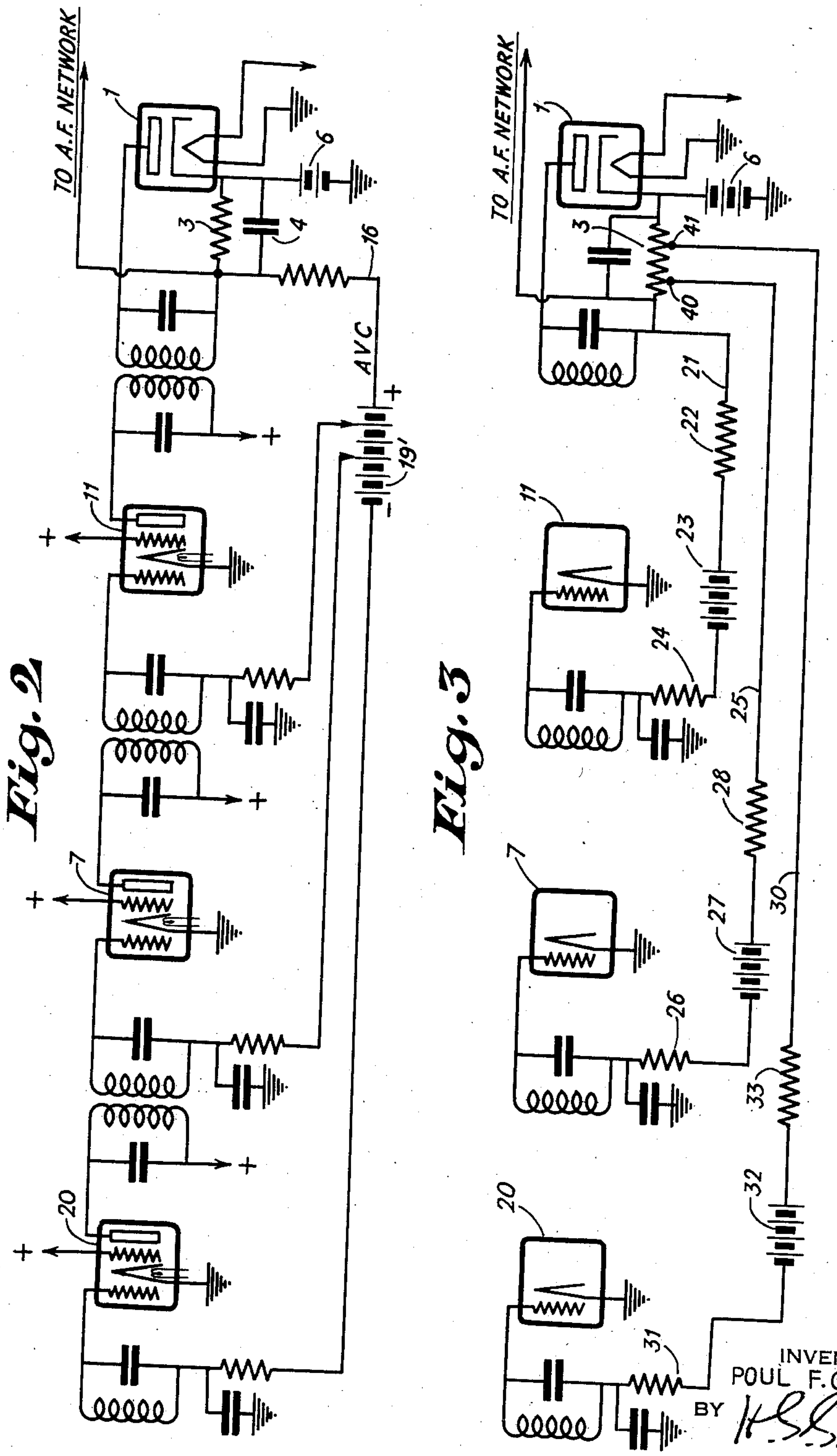

Fig. 2

Fig. 3

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Fig. 4

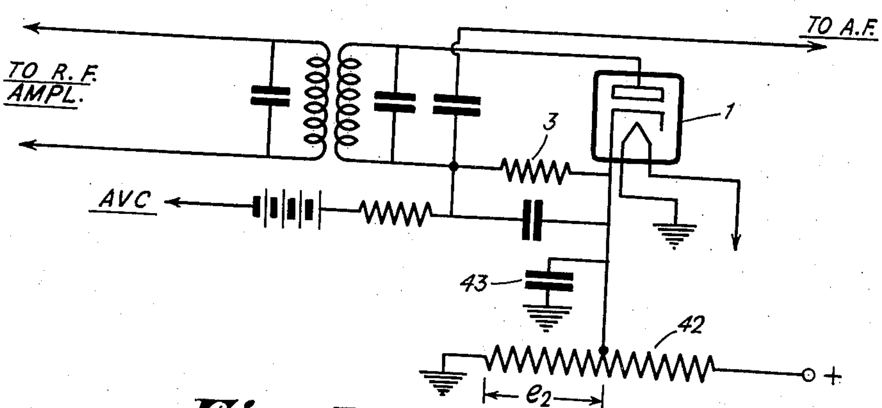


Fig. 5

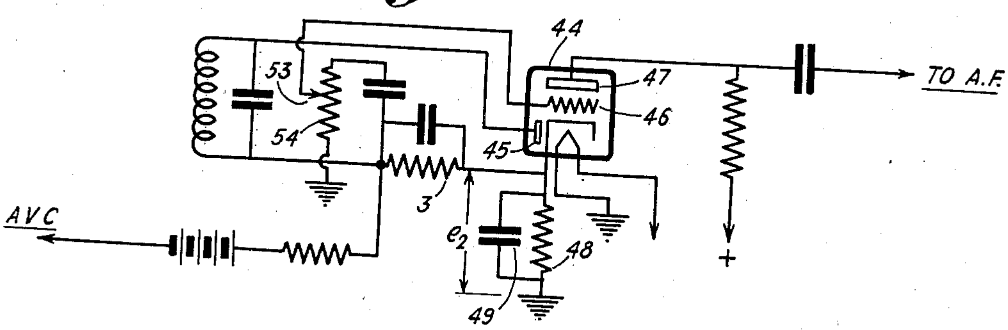
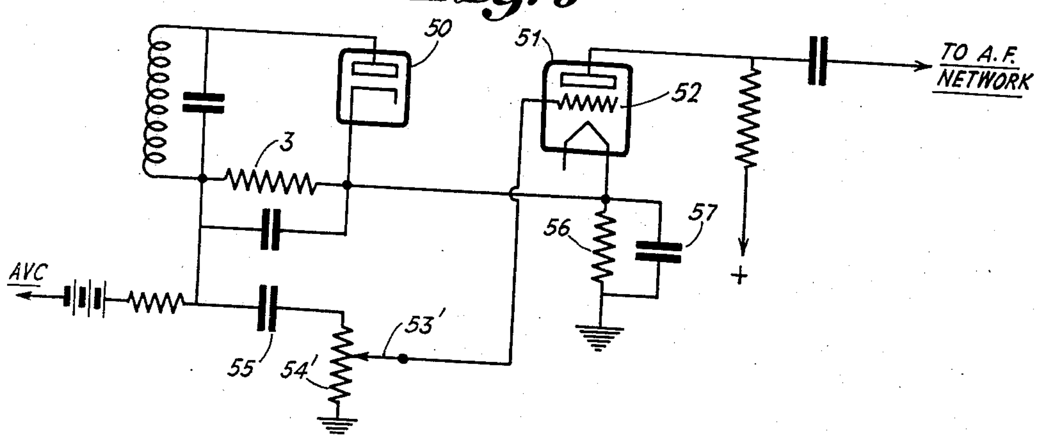


Fig. 6



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UNITED STATES PATENT OFFICE

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AUTOMATIC VOLUME CONTROL CIRCUITS

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Application September 20, 1935, Serial No. 41,359

11 Claims. (Cl. 250—20)

My present invention relates to gain control networks for radio signaling systems, and more particularly to automatic volume control arrangements for radio receivers.

One of the main objects of my present invention is to provide an automatic volume control arrangement for a radio receiver of the type utilizing a diode demodulator as a gain control tube, and wherein the anode and cathode of the demodulator may be maintained at a normal positive potential with respect to the cathodes of the tubes to be controlled, and an auxiliary negative potential source being utilized to provide the normal minimum biasing voltage for the signal control grids of the controlled tubes.

Another important object of the invention is to provide an automatic volume control arrangement for a radio receiver of the type utilizing battery sources for energization of the receiver tube electrodes, and the volume control arrangement employing the diode demodulator of the receiver as the gain control tube, where the diode anode and cathode may be maintained at a normal positive potential with respect to the filaments or cathodes of the controlled transmission tubes and the diode filament, and where a battery is utilized as a source of biasing potential to provide a normal negative minimum grid potential for the controlled transmission tubes.

Another object of the invention is to provide an automatic gain control arrangement for a battery operated radio receiver which employs a diode as a detector, wherein the anode of the diode may be prevented from assuming a normal potential with respect to the filaments of the controlled amplifiers which is negative, and a negative voltage source being connected in the automatic gain control connection to the signal control grids of the controlled amplifiers for providing the normal negative grid bias for the controlled amplifiers.

Still other objects of the invention are to improve generally the simplicity and efficiency of automatic volume control networks for radio receivers, and more especially to provide automatic volume control arrangements which are not only reliable in operation, but are economically manufactured and assembled in radio receivers whether of the battery or alternating current operated type.

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, as to both 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 is a circuit diagram of a battery operated receiver embodying the present invention,

Fig. 2 is a modification of the invention, as applied to an A. C. operated receiver,

Fig. 3 shows still another embodiment of the invention,

Fig. 4 shows an alternative form of the diode demedulator network of a receiver embodying the present invention,

Fig. 5 shows a modification of the arrangement of Fig. 4,

Fig. 6 shows another variation of the arrangement shown in Fig. 4,

Fig. 7 shows a receiver of the alternating current type embodying the present invention.

Referring now to the accompanying drawings, wherein like reference characters in the different figures correspond to similar circuit elements, there is shown in Fig. 1 a radio receiving system of a general type. In order to render the present disclosure simple to understand, the receiving system is shown only in its essential elements. For example, the receiver may be of the superheterodyne type, or of the tuned radio frequency type. In either case, the demodulator is preceded by one, or more, stages of signal frequency amplification, and is followed by the usual audio frequency network.

Let is be assumed that the receiver shown in Fig. 1 is of the superheterodyne type; in that case the demodulator is the second detector, and the demodulator comprises a diode of the indirectly heated cathode type. The diode 1 has its anode connected to its cathode through a path including the signal input circuit 2 arranged in series with the diode load resistor 3. The circuit 2 is resonated to the operating intermediate frequency, and the usual intermediate frequency by-pass condenser 4 is connected in shunt with load resistor 3. The heater, or filament, 5 of the cathode 1 has its terminals connected across a heating battery A, the negative terminal of which may be grounded. The cathode of diode 1 is maintained at a predetermined positive potential with respect to ground by inserting a battery 6 between ground and the cathode lead. Thus, when signals are not impressed on the circuit 2, the anode and cathode of tube 1 are at a predetermined positive potential with respect to the heater 5.

The stages preceding circuit 2 are of the intermediate frequency amplifier type; the tube 7 has its signal grid and cathode connected to a signal input circuit 8, and its tuned plate circuit 9 is coupled to the tuned input circuit 10 of the following amplifier 11. The tuned plate circuit 12 of amplifier 11 is coupled to the demodulator input circuit 2. It will be understood that each of circuits 8, 9, 10 and 12 is resonated to the operating intermediate frequency. The heater elements, or filaments, of tubes 7 and 11 are connected in shunt with the heater 5 of diode 1 across the heating battery A. The battery source for energizing the plates and screen grids of tubes 7 and 11 is not shown in order to preserve simplicity of disclosure, but those skilled in the art will fully appreciate that the usual battery sources are employed in the type of receiver shown in Fig. 1. The numeral 13 designates the intermediate frequency signal source feeding the input circuit 8. This signal source 13 may comprise the customary signal collector followed by one, or more, stages of radio frequency amplification, and a frequency changer network. This frequency changer network may embody the usual first detector and local oscillator networks. For example, the networks preceding amplifier 7 may be of the type shown in Fig. 1 of my co-pending application, Serial No. 29,014, filed June 29, 1935, patented May 17, 1938, as U. S. Patent 2,117,664.

The audio component of demodulated intermediate frequency energy is impressed upon a subsequent audio frequency network through an adjustable connection including condenser 14, and the adjustable tap 15 may be adjusted to any point on resistor 3 to vary the audio input to the audio network. The latter may comprise one, or more, stages of audio frequency amplification followed by a reproducer. The direct current component of demodulated energy is employed for automatic gain control of one, or more, signal transmission tubes preceding the demodulator 1.

The automatic volume control arrangement (denoted by the symbols AVC) comprises the lead 16 connected between the anode side of resistor 3 and the low alternating potential sides of the input circuits 10 and 8. The AVC connections to the input circuits 8 and 10 include filter resistors 17 and 17', and the filter resistor 18 is connected in the AVC connection to the anode side of load resistor 3. In order to provide the normal negative minimum grid bias for tubes 7 and 11, a negative voltage source 19 is connected in the AVC lead. Thus, when no signals are impressed on the receiver, the effective operating negative grid bias for each of tubes 7 and 11 is the sum of the negative and positive voltages of sources 19 and 6.

Of course, the AVC connection may be extended to any of the other tubes preceding the I. F. amplifiers, and, as shown in my aforesaid patent, the signal amplifiers preceding the frequency changer network may be regulated in gain, and the first detector may have its gain regulated. When signals are received, the effective negative bias voltage on the controlled tubes is increased due to the connection of lead 16 to the anode side of resistor 3. In other words, as the amplitude of signals impressed on circuit 2 increases, the variable negative bias transmitted through lead 16 to the signal grids of the controlled transmission tubes increases, and the gain of the controlled tubes decreases. This maintains the signal input to the demodulator 1 substantially uniform in spite of wide variation of signal amplitude at the signal collector of the receiver.

In the case of the receiver being of the tuned radio frequency type, it will be understood that the stages preceding the demodulator will have their input circuits each tuned to the carrier frequency being received, and that the tunable input circuits will then be uni-controlled by the usual gang condenser construction. In any event the automatic volume control arrangement will be such that the diode demodulator of the receiving system is employed as the gain control tube, and the diode anode will be at a predetermined potential which may be positive with respect to the cathodes of the controlled transmission tubes. However, in so far as the signal grids of the controlled tubes are concerned, they are increased in negative bias as the signal amplitude increases. This is accomplished in a simple and effective manner by employing as the demodulator a diode having an indirectly heated cathode, and maintaining the cathode of the diode positive with respect to the interconnected tube filaments of the system; and utilizing an auxiliary negative grid biasing battery to provide the normal negative minimum grid bias for the controlled tubes.

In Fig. 2 there is shown a modification of the arrangement of Fig. 1 wherein the auxiliary normal negative grid biasing voltages for the controlled tubes are different, but supplied by common battery 19'. It will be seen that the circuit elements of the receiving system are not shown substantially the same as those shown in Fig. 1. That is to say, the diode 1 has its cathode elevated to a predetermined potential, which may be positive, above ground by the battery 6, and the AVC lead 16 includes the auxiliary negative biasing battery 19'. An additional amplifier 20 is shown preceding the amplifiers 7 and 11.

The signal grid of amplifier 20 is connected to the negative terminal of the source 19'; the signal grid of amplifier 7 is connected to a point of less negative potential on the source 19'; and the grid of tube 11 is connected to a point on source 19 which is still less negative in magnitude.

The tubes 20, 7, 11, are shown, by way of example, as of the indirectly heated type, and can be used in the A. C. operated set. The heater of diode 1 and the cathode of tubes 20, 7 and 11 are shown at ground potential. It will be seen that the normal negative grid bias for each of the controlled tubes differs, and in each case is equal to the sum of the positive voltage from source 6 and the particular value of negative voltage supplied from the source 19'. When the AVC action commences, due to the reception of signals, there will be an increase in the negative bias supplied to the signal grids of each of the controlled amplifiers, but the magnitude of these biases will decrease in the order of the arrangement of the tubes looking towards the demodulator 1.

In Fig. 3 is shown a still more generalized embodiment of the invention wherein each of the signal grids of amplifiers 20, 7 and 11 not only has a different normal minimum negative bias, but the AVC bias differs. Thus, the anode side of the diode load resistor 3 is connected by lead 21 to the signal grid of amplifier 11 through a path which includes the filter resistor 22, the auxiliary negative grid biasing battery 23, and the filter resistor 24. The signal grid of the next preceding amplifier 7 is connected to a point on load resistor 3 which is closer to the cathode of tube 1. The lead 25 includes the filter resistor 26, the auxiliary grid biasing battery 27, and the filter resistor 28. The signal grid of the next preceding amplifier 20 is connected to a point on load resistor 3 through a connection 30, and this latter point on resistor 3 is still closer to the cathode side of resistor 3. The connection 30 includes the filter resistor 31, the auxiliary grid biasing battery 32, and the filter resistor 33.

In order to preserve simplicity of disclosure, the couplings between the amplifiers 20, 7 and 11 are not shown, and the common heater circuit is also omitted. It is believed that those skilled in the art will readily understand the manner in which the normal negative signal grid bias on each of the controlled amplifiers is calculated. Thus, the negative grid bias for tube 20 will be equal to the sum of the voltage of source 6 and the negative voltage of source 32; in the case of tube 7 the normal grid bias will be equal to the sum of the negative voltage from battery 27 and the voltage from source 6; and in the case of tube 11 it will be equal to the sum of the voltages from source 6 and battery 23. When signals are received and the AVC bias is generated, the effective negative grid bias in the case of each of the controlled tubes will depend upon the point of its connection on resistor 3. For example, the signal grid of tube 11 will have impressed on it the voltage drop across resistor 3; in the case of tube 7 there will be impressed on the signal grid the voltage drop between the cathode side of resistor 3 and the point 40; and in the case of tube 20 the gain control voltage will be equal to the voltage drop developed across that portion of resistor 3 which is between point 41 and the cathode side of the resistor.

In each of Figs. 1, 2 and 3, it will be observed that the battery 6 may be used to raise the diode anode at a normal positive potential with respect to the cathodes of the controlled tubes. But in cases where it is not desired to have this voltage relation the battery may be omitted. In Fig. 4 is shown a modification of the demodulator network wherein a positive voltage for the diode anode is obtained by connecting the diode cathode to a suitable point on the supply voltage bleeder resistor. Thus, the numeral 42 denotes a bleeder resistor one side of which is grounded, and the other side of which is connected to a point of positive potential of the power supply network. The anode of the diode 1 is connected to the cathode through the load resistor 3, and the cathode of the diode is connected to an intermediate point on the bleeder resistor. The symbol e_2 denotes the positive potential which is employed for raising the diode anode and cathode above ground with respect to the heater elements of the controlled tubes. A by-pass condenser 43 is connected between ground and the cathode lead of tube 1. It will be understood that the remaining portions of the circuit elements are the same as those shown in Fig. 1. The bleeder resistor may be connected across any desired source of D. C. power. This may be the filter network of the rectifier output of an alternating current supply. As is the case of Fig. 1, the auxiliary biasing battery is disposed in the AVC lead.

In Fig. 5 is shown a modification of the arrangement in Fig. 4 wherein the positive voltage e_2 is obtained by the voltage drop across an impedance in the space current path of an electron discharge device. For example, tube 44 is of the multi-function type wherein there is included within the tube envelope an indirectly heated cathode, a diode anode 45, a grid 46 and a plate 47. The diode anode 45 is disposed adjacent a portion of the cathode, and is outside the electron stream flowing through the grid 46 to the plate 47. The diode load resistor 3 develops the direct current and audio frequency components of the signal currents. An impedance 48, in particular a resistor, is disposed in the grounded cathode circuit of tube 44, the resistor being suitably by-passed by a condenser 49. The voltage drop e_2 across resistor 48 is utilized as the positive voltage for raising the diode anode 45 above ground by the predetermined positive voltage. Of course, in this modification the controlled amplifiers have their cathodes at ground potential, and as in the case of Fig. 1, the auxiliary negative biasing battery is disposed in the AVC lead. In this modification, the audio component is derived from grounded grid leak 54. The tap 53 from grid 46 acts as a manual volume control. The ungrounded side of leak 54 is connected to the anode side of resistor 3 through an audio by-pass condenser. Thus, the voltage e_2 is used here to bias the grid 46 to a proper negative value.

In Fig. 6 is shown still another modification wherein the demodulator diode 50 is disposed outside the electron discharge tube envelope 51. The load resistor 3 again supplies the gain control voltage and the audio component. The control grid 52 of tube 51 is adjustably connected, by adjustable tap 53′, to the grounded resistor 54′, the ungrounded side of which is connected to the anode side of resistor 3 through condenser 55. The resistor 56, disposed in the cathode circuit of tube 51, has one side thereof grounded, and its other side is connected to the cathode side of resistor 3. A suitable by-pass condenser 57 is connected in shunt with resistor 56. The voltage drop across resistor 56 is employed for two functions. In the first place it acts to raise the anode of demodulator 50 above ground in the absence of signals; and in the second place it provides the normal negative grid bias for the control grid 52 of audio amplifier 51.

In Fig. 7 is shown a modification of this invention as applied to the receiving system shown in Fig. 1 of my aforesaid patent. This receiving system is of the alternating current operated type, and it is sufficient for the purposes of the present disclosure only to show a portion of the bleeder section of the power supply network. Thus, there is shown a series connection of two resistors 60 and 61, one end of resistor 61 being grounded. One side of resistor 60 is connected to the positive side of the power supply network, while the grounded side of resistor 61 is connected to the negative side of the power supply network. The receiving system is of the superheterodyne type, and there is only shown one of the intermediate frequency amplifier tubes 63, and the diode tube 64. This tube 64 includes a diode which acts as a control device for the signal grid biasing network of amplifier 63.

The signal input circuit 65 of the demodulator diode is connected between the anode 66 and the cathode 67, a resistor 68 being connected between the low alternating potential side of input circuit 65 and the cathode 67. The signal input circuit 70 of tube 63 has its low alternating potential side connected to an intermediate point on load resistor 68 through a path which includes the filter resistor 71, the auxiliary negative biasing battery 72 and the filter resistor 73. A lead 83 connects the cathode 67 to the junction of resistors 61 and 60. The audio frequency component of demodulated signal current is transmitted through condenser **90** to the subsequent audio frequency network. The numeral **100** designates the intervening transmission network between amplifier **63** and the diode device. It will now be seen that in Fig. 7 the —4.5 volts auxiliary source **72** performs the function of the normal biasing diode of Fig. 1 of my patent.

While I have indicated and described several systems for carrying my invention into effect, it will be clear to one skilled in the art that my invention is by no means limited to the particular organizations 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. In a receiving circuit, an electron discharge tube disposed in a signal transmission network, said tube including at least a cathode, signal grid and output electrode, a demodulator device including at least an electron emission element and a cold electrode, a load impedance connected between said cold electrode and emission element, a transmission network coupling the output electrode of the first tube and said cold electrode and emission element, voltage means for maintaining said cold electrode and emission element at a potential which is positive with respect to the cathode of said signal transmission tube in the absence of signals, said voltage means being connected between said cathode and the junction of said load impedance and said emission element, a gain control connection between the signal control grid of said transmission tube and a point on said load impedance which is negative, when signals are received, with respect to the emission element side of the impedance, and a voltage source disposed in said gain control connection in polarity opposition to said maintaining means for normally maintaining the signal grid of the transmission tube negative with respect to the cathode thereof during the absence of signals thereby to establish the maximum gain of said tube.

2. In combination with a signal amplifier, said amplifier including an electron discharge tube provided with a cathode, control grid and plate, a diode demodulator including a signal input circuit connected between the anode and cathode thereof, a heater element for the cathode of the demodulator, a load resistor connected between the demodulator anode and cathode electrodes, means for establishing the cathode of the amplifier and the demodulator heater element at a common fixed potential, voltage means for establishing the demodulator cathode and anode at a potential which is positive with respect to said fixed potential in the absence of signals, said voltage means being connected between said amplifier cathode and the junction of said resistor and diode cathode, and a gain control connection between the anode side of said load resistor and the signal grid of the amplifier, said gain control connection including a negative voltage source for maintaining the amplifier grid at a normal negative potential with respect to the amplifier cathode in the absence of signals thereby to establish the maximum gain of said amplifier tube.

3. In combination with a signal amplifier, said amplifier including an electron discharge tube provided with a cathode, control grid and plate, a diode demodulator including a signal input circuit connected between the anode and cathode thereof, a heater element for the cathode of the demodulator, a load resistor connected between the demodulator anode and cathode electrodes, means for establishing the cathode of the amplifier and the demodulator heater element at a common fixed potential, means for preventing the demodulator cathode from assuming a potential which is negative with respect to said fixed potential in the absence of signals, and a gain control connection between the anode side of said load resistor and the signal grid of the amplifier, said gain control connection including a negative voltage source for maintaining the amplifier grid at a normal negative potential with respect to the amplifier cathode in the absence of signals thereby to establish the maximum gain of said amplifier tube, and said preventing means comprising a voltage source connected in polarity opposition to said negative source to maintain the demodulator cathode and anode positive with respect to the said heater element and said positive voltage source being connected between said amplifier cathode and the junction of said resistor and diode cathode.

4. In combination with a signal amplifier, said amplifier including an electron discharge tube provided with a cathode, control grid and plate, a diode demodulator including a signal input circuit connected between the anode and cathode thereof, a heater element for the cathode of the demodulator, a load resistor connected between the demodulator electrodes, means for establishing the cathode of the amplifier and the demodulator heater element at a common fixed potential, means for maintaining the demodulator cathode and anode at a desired positive potential with respect to said fixed potential, and a gain control connection between the anode side of said load resistor and the signal grid of the amplifier, said gain control connection including a negative voltage source connected in polarity opposition to the maintaining means for maintaining the amplifier grid at a normal negative potential with respect to the amplifier cathode, at least one additional amplifier disposed between said demodulator and the first amplifier, and a direct current connection between the signal grid of the additional amplifier and a point on said voltage source which is positive with respect to the point thereon to which the signal grid of the first amplifier is connected.

5. In combination with a signal amplifier, said amplifier including an electron discharge tube provided with a cathode, control grid and plate, a diode demodulator including a signal input circuit connected between the anode and cathode thereof, a heater element for the cathode of the demodulator, a load resistor connected between the demodulator electrodes, means for establishing the cathode of the amplifier and the demodulator heater element at a common fixed potential, means for maintaining the demodulator cathode and anode at a positive potential with respect to said fixed potential, and a gain control connection between the anode side of said load resistor and the signal grid of the amplifier, said gain control connection including a negative voltage source in polarity opposition to said maintaining means for maintaining the amplifier grid at a normal negative potential with respect to the amplifier cathode, an additional amplifier disposed between the first amplifier and the demodulator, a direct current connection between the signal grid of

the additional amplifier and a point on said load resistor which is at a different potential when signals are received than the point to which the first amplifier is connected, and said second connection including a source of negative biasing voltage for the signal grid of the additional amplifier.

6. In an automatic volume control arrangement for a radio receiver, which receiver is of the type including a diode demodulator, a signal transmission tube feeding the demodulator, and an audio amplifier, means for maintaining the diode anode and cathode at a positive potential with respect to a predetermined fixed direct current potential point, means for maintaining the cathode of the signal transmission tube at the potential of said fixed point, additional means connected in series with said maintaining means between said fixed potential point and the signal grid of said transmission tube and in polarity opposition to the maintaining means for normally maintaining the transmission tube signal grid negative with respect to the cathode thereof in the absence of signals, and said first means additionally providing the audio amplifier grid bias.

7. In an automatic volume control arrangement for a radio receiver, which receiver is of the type including a diode demodulator, a signal transmission tube feeding the demodulator, and an audio amplifier, means for maintaining the diode anode and cathode at a positive potential with respect to a predetermined fixed direct current potential point, means for maintaining the cathode of the signal transmission tube at the potential of said fixed point, additional means connected between said fixed potential point and the signal grid of said transmission tube for normally maintaining the transmission tube signal grid negative with respect to the cathode thereof in the absence of signals, and said first means additionally providing the audio amplifier grid bias, said demodulator and audio amplifier electrodes being disposed in a common tube envelope.

8. In an automatic volume control arrangement for a radio receiver, which receiver is of the type including a diode demodulator, a signal transmission tube feeding the demodulator, and an audio amplifier, means for maintaining the diode anode and cathode at a positive potential with respect to a predetermined fixed direct current potential point, means for maintaining the cathode of the signal transmission tube at the potential of said fixed point, additional means connected in series with said maintaining means between said fixed potential point and the signal grid of said transmission tube for normally maintaining the transmission tube signal grid negative with respect to the cathode thereof in the absence of signals, and said first means additionally providing the audio amplifier grid bias, said fixed potential point being ground, and said positive potential means being dependent upon the space current of the audio amplifier.

9. In combination with a source of electrical waves, a wave transmission tube coupled to the source and being provided with at least a cathode, output electrode and a gain control electrode, a wave rectifier tube including at least a cathode and a cold electrode, means for impressing waves upon the rectifier, an impedance connected between the rectifier cathode and cold electrode for developing thereacross a uni-directional voltage dependent in amplitude upon the wave amplitude, a voltage source establishing said rectifier cathode and cold electrode at a positive voltage with respect to a fixed potential, means for establishing the transmission tube cathode at said fixed potential, said voltage source being connected between said transmission tube cathode and the junction of said impedance and rectifier cathode, a direct current voltage connection, acting as a gain control circuit, between the said gain control electrode and a point on the impedance such that the uni-directional voltage is applied to the gain control electrode in a negative sense, and a voltage source being included in said gain control connection and providing a negative voltage in polarity opposition to the positive voltage thereby to provide a minimum negative potential for the said gain control electrode in the absence of waves and establishing the maximum gain of said transmission tube.

10. In an automatic volume control arrangement for a radio receiver, which receiver is of the type including a diode demodulator, a signal transmission tube feeding the demodulator, and an audio amplifier, means for maintaining the diode anode and cathode at a positive potential with respect to a predetermined fixed direct current potential point, means for maintaining the cathode of the signal transmission tube at the potential of said fixed point, additional means connected in series with said maintaining means between said fixed potential point and the signal grid of said transmission tube and in polarity opposition to the maintaining means for normally maintaining the transmission tube signal grid negative with respect to the cathode thereof in the absence of signals, and said first means additionally providing the audio amplifier grid bias, and a gain control connection between a gain control electrode of the transmission tube and said diode.

11. In combination with a source of electrical waves, a wave transmission tube coupled to the source and being provided with at least a cathode, output electrode and a gain control electrode, a wave rectifier tube including at least a cathode and a cold electrode, means for impressing waves upon the rectifier, an impedance connected between the rectifier cathode and cold electrode for developing thereacross a uni-directional voltage dependent in amplitude upon the wave amplitude, a voltage source establishing said rectifier cathode and cold electrode at a positive voltage with respect to a fixed potential, means for establishing the transmission tube cathode at said fixed potential, said voltage source being connected between said transmission tube cathode and the junction of said impedance and rectifier cathode, a direct current voltage connection, acting as a gain control circuit, between the said gain control electrode and a point on the impedance such that the uni-directional voltage is applied to the gain control electrode in a negative sense, a voltage source being included in said gain control connection and providing a negative voltage in polarity opposition to the positive voltage thereby to provide a minimum negative potential for the said gain control electrode in the absence of waves, an electron discharge device having input electrodes coupled to points of different alternating potential on said impedance, and an impedance in the space current path of said device to provide said first voltage source.

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