

June 13, 1933.

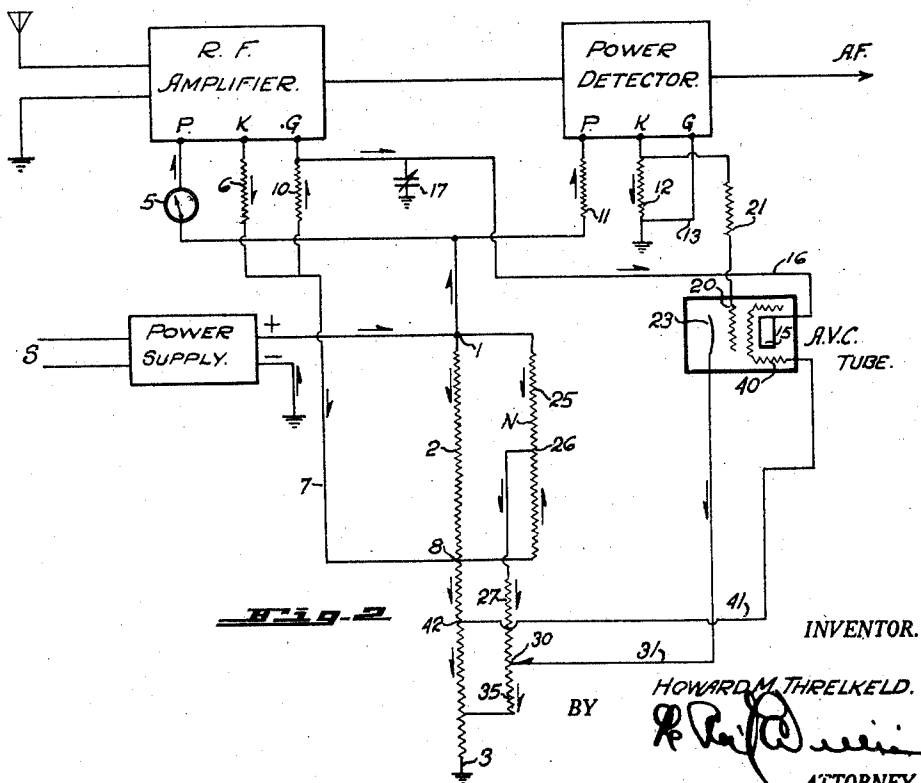
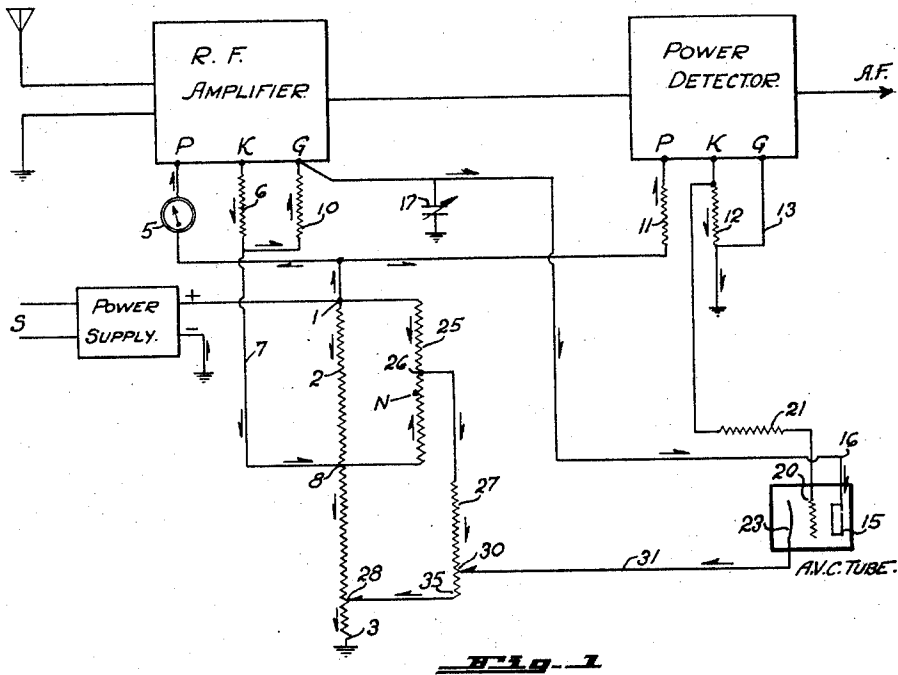
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RADIO APPARATUS

Filed Sept. 14, 1931

2 Sheets-Sheet 1



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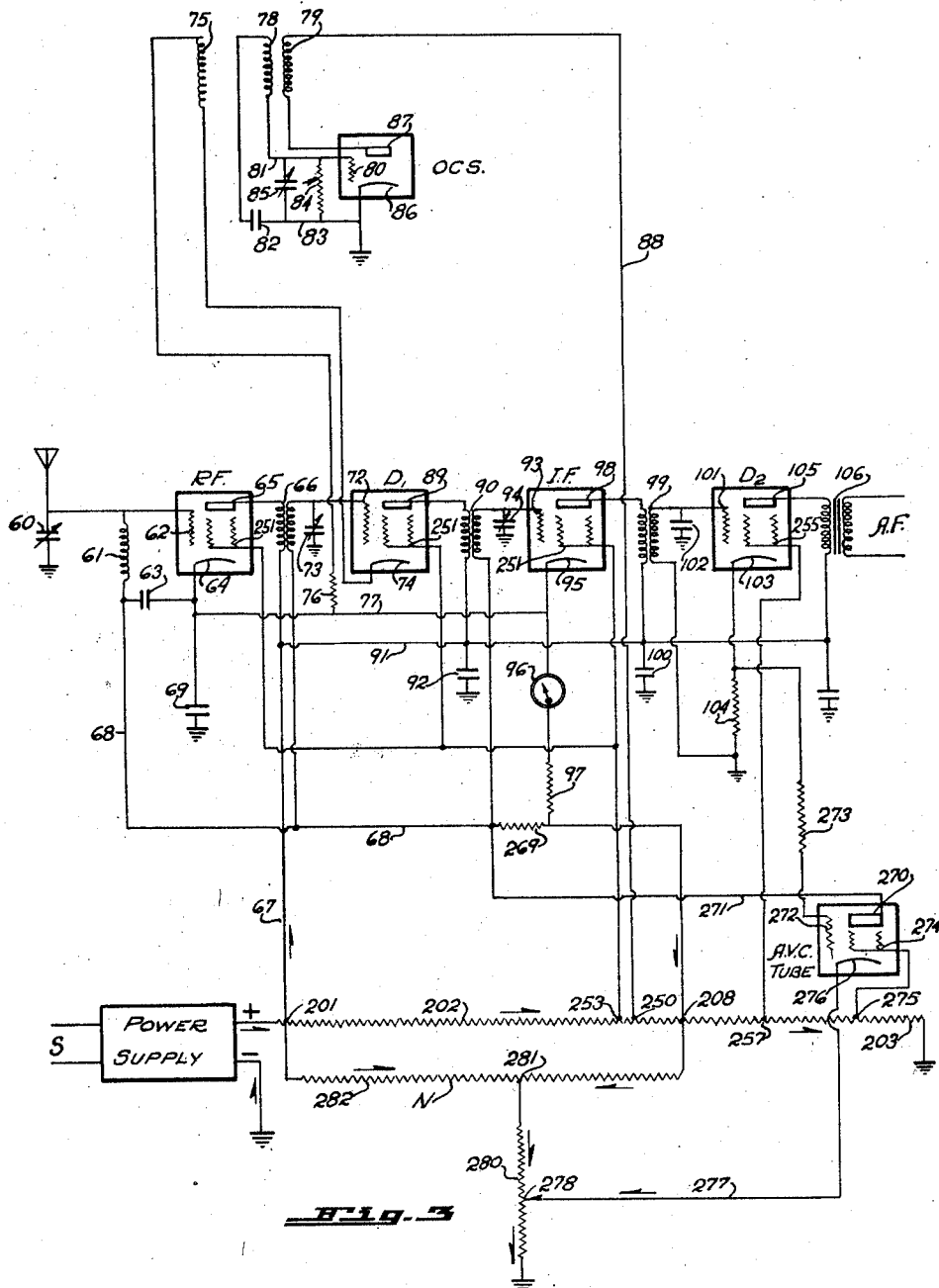
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2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

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## RADIO APPARATUS

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This invention relates to radio apparatus, and particularly to the automatic control of volume. In systems wherein a separate tube is used to automatically maintain a constant volume of reproduction, it has been found that there is an appreciable variation of volume with respect to signal strength. This is primarily due to the fact that the power supply potential applied to the automatic volume control tube changes, due to the poor regulation of the customary power supplies. Thus, it is usual to impress rectified and filtered current on a voltage divider, usually a series of resistances, and apply the various potentials along these resistances to the various portions of the set, as needed. Obviously, the variation in plate current through the R. F. tubes due to variation of signal strength, results in variation of potential along various portions of the voltage divider.

An object of this invention is to devise a system in which the volume will be maintained constant over a wide range of signal strength.

An additional object is to devise a system in which the characteristic of the volume control may be very simply and easily predetermined.

In general, this invention contemplates the selection of two points on the voltage divider having opposite voltage characteristics. Thus, upon a decrease in load of the R. F. amplifiers, one point may have a rising voltage characteristic, while the other point may have a falling voltage characteristic. These two points are suitably bridged in such manner that a neutral point having a substantially constant voltage characteristic is created. This neutral point, or as later explained a point adjacent thereto, is suitably connected to the cathode of the automatic volume control tube hereinafter abridged to A. V. C. tube and results in the application of a potential on the cathode, which is substantially constant with respect to the ground

potential of the system. This permits the potential of the other electrodes to vary in accordance with the laws governing the various portions of the system and permits these other electrodes to more faithfully perform their automatic volume control functions.

This system is particularly effective when used in connection with a detector in which the variation of grid potential during detection has a wide range, such as in so-called power detectors.

In the drawings,

Figure 1 is a diagrammatic showing of a receiver having a three-element A. V. C. tube connected in accordance with this invention;

Figure 2 is similar to Figure 1 with the exception that a four-element A. V. C. tube is disclosed; and

Figure 3 shows the application of this invention to a superheterodyne type of circuit.

Referring to Figure 1, an antenna and ground are shown connected to an R. F. amplifier. This amplifier may be of any type whatsoever, having any number of stages and using any suitable types of tubes. For the sake of simplicity, this amplifier is shown as having three connections, P, K and G, being the plate, cathode and grid connections, respectively. It is understood, of course, that the various stages of the amplifier may have these common connections so broken up by resistances and condensers that any desired potentials may be obtained on the various electrodes and undesirable reaction between the stages may be eliminated. The R. F. amplifier leads into a power detector having three similar connections and finally energizes suitable audio-frequency amplifiers and apparatus (not shown).

In order to energize the set, a power supply of the usual type, having a rectifier and suitable filters and chokes, may be provided and connected to a source of alternating current. The positive potential of the power

supply is connected to terminal 1 of the voltage divider 2, 1 usually consisting of one or more resistances. The other terminal 3 of voltage divider 2 is grounded and connects with the grounded negative terminal of the power supply. Thus, during the operation of the power supply there will be current flowing through the voltage divider all the time. Terminal P of the R. F. amplifier is connected through a tuning meter 5 to terminal 1 of voltage divider 2. Cathode K of R. F. amplifier is connected through a suitable resistance 6 and lead 7 to point 8 on voltage divider 2. Points 8 and 1 are so chosen with respect to each other that the difference in potential thereof is suitable for energizing the plate circuits of the R. F. amplifier. In order to obtain the grid bias in the R. F. amplifier, grid terminal G is connected to lead 7 through a resistance 10, whose function will be explained later. Due to the drop in potential along resistance 6, cathode terminal K will be at a positive potential with respect to lead 7. Grid terminal G, which is connected to lead 7 through resistance 10 of a suitable value, will, therefore, be maintained negative with respect to cathode K.

The power detector plate terminal P is similarly connected to terminal 1 of the voltage divider 2, through a resistance 11. This resistance is inserted merely to adjust the potential of P to the proper value. Obviously, this same effect may be obtained by connecting the plate terminal of the power detector to a suitable point along voltage divider 2. Cathode K of the power detector is grounded through resistance 12. Grid G of the power detector is connected through a lead 13 to the grounded end of resistance 12. The grid bias in the power detector will, therefore, be maintained in substantially the same manner as in the R. F. amplifier. The actual values of the various potentials may be adjusted by suitably adjusting the values of the various resistances.

The three-element A. V. C. tube has its plate and grid connected in the usual manner. The plate 15 is connected through lead 16 to the grid terminal of the R. F. amplifier. A variable condenser 17 is connected between lead 16 and ground. Grid 20 is connected through a resistance 21 to the cathode of the power detector.

In order to provide a connection through cathode 23 of the A. V. C. tube, two points, 1 and 8, on the voltage divider 2 are connected through a resistance 25. It is not necessary that resistance 25 be connected to the same points on voltage divider 2 as the anode and cathode of the R. F. amplifier. It is only necessary to use two points along voltage divider 2 which have opposite voltage characteristics with a change of load through the R. F. amplifiers. For simplicity of connections, points 1 and 8 are taken. Along a

suitable point 26, which may be experimentally determined, one end of resistance 27 is connected. As explained later, point 26 is close to neutral point N, the latter having a constant potential for variations of load. The other end of resistance 27 is connected to a point 28 on voltage divider 2. Resistance 27 is provided with a sliding contact 30, thus making it a potentiometer. Slider 30 is connected through a lead 31 to cathode 23 of the A. V. C. tube.

It is understood, of course, that the various points along voltage divider 2, as well as the values of the various resistances, are so chosen that the various electrodes of all the tubes are operated at proper potentials.

The operation of the system, as far as the volume control function is concerned, is substantially as follows:

Assume that there is a sudden surge of signal strength through the R. F. amplifier. This will result in increased plate current through it and permit increased current to flow through the plate circuit of the power detector. During the normal operation of the system, anode 15 and grid 20 of the automatic volume control tube will be at certain predetermined potentials. Upon the increased plate current through the power detector, there will be an increase in the drop through resistance 12, with the result that the cathode K of the detector will tend to become more positive. This will result in the potential of grid 2 becoming more positive and permitting greater space current to flow through the A. V. C. tube.

Assuming the conventional flow of current from positive to negative terminals of the system, it is clear that the A. V. C. tube will draw more current through resistance 10. The drop along this resistance will, therefore, become greater, with the result that grid terminal G of the R. F. amplifier will tend to become more negative with respect to the cathode of the R. F. amplifier. This will, therefore, cut down the plate current through the R. F. amplifier to normal value. The time constant of the plate circuit of the A. V. C. tube may be adjusted by using proper values for the resistance 10 and condenser 17.

As the load through the R. F. amplifier tends to increase, due to an increase in volume, more current is by-passed through the R. F. amplifier tubes and less through voltage divider 2. This results in the potential of point 1 dropping somewhat and the potential of point 8 rising somewhat with respect to normal values. Point 26 on resistance 25, which is almost at a constant potential with respect to ground, will thus tend to maintain cathode 23 of the A. V. C. tubes at a substantially constant value, taking into account the poor regulation of lower portion 35 of resistance 27 and the por-

tion of the divider below point 28. As the space current through the A. V. C. tube tends to vary, the drops through portion 35 and the portion of voltage divider 2 below point 28 varies. Hence, by moving point 26 a little away from the theoretical neutral point, indicated at N, the potential applied to resistance 27 will tend to drop somewhat as the R. F. amplifier tends to pass more current therethrough.

This point 26, however, may vary on one side or the other of the neutral point and may be experimentally determined. In fact, by varying the position of point 26 with respect to the true neutral point N, the characteristic curve of the volume control system may be caused to slope upwardly or dip downwardly, thus giving somewhat greater volume in the first case and somewhat less volume in the second case for an increase in signal strength.

In order to permit accurate tuning of the set, the usual tuning meter 5 is disposed in the plate circuit of the R. F. amplifier. When tuned to resonance, the plate current through the R. F. amplifier will be at a minimum value. This will reflect itself in proper meter readings.

Resistance 21 to grid 20 of the A. V. C. tube is provided in order to limit the grid current through the A. V. C. tube in the event that the potential of grid 20 will swing positive with respect to cathode 23 of the A. V. C. tube. This, of course, is possible with a sufficiently large surge through the power detector.

The actual volume of the set may be varied by moving slider 30 along resistance 27.

In Figure 2, the A. V. C. tube is provided with a shield grid 40. This additional grid is connected by a lead 41 to point 42 on voltage divider 2. Point 42 is so chosen that a suitable potential is imposed on the shield grid. In order to compensate for the regulation of potential at point 42 of the voltage divider, resistance 27 will have to be connected at a different point 26' on resistance 25. In this instance, some additional poor regulation is introduced in the cathode circuit of the A. V. C. tube to compensate for the inherently poor regulation of the applied potential on screen grid 40 of this tube.

In Figure 3 a superheterodyne circuit is shown with an A. V. C. circuit. This superheterodyne, in a simple form, comprises an antenna tuning condenser 60, having one terminal grounded and the other terminal connected to an inductance 61. Inductance 61 is connected to grid 62 and through a blocking condenser 63, to cathode 54 of the radio frequency amplifier. The anode 65 of the R. F. tube is connected through the primary of the transformer 66 to a lead 67. The low side of inductance 61 is connected to a lead

68. Cathode 64 is grounded, as far as radio-frequency impulses are concerned, through a condenser 69. The secondary of transformer 66 has one terminal connected to lead 68, while its other terminal is connected to grid 72 of detector tube D'. A tuning condenser 73 is connected between grid 72 and ground. Cathode 74 is connected through a pick-up coil 75 and biasing resistance 76, to a lead 77. Pick-up coil 75 is inductively associated with coils 78 and 79 in the grid and plate circuits, respectively, of the oscillator tube. Grid 80 of the oscillator tube is connected to coil 78 by lead 81, and a blocking condenser 82 is inserted in return lead 83 to the cathode. A grid resistance 84 and tuning condenser 85 are connected across from grid 80 to cathode 86 of the oscillator tube. Plate 87 of the oscillator tube is connected through coil 79 to lead 88. Anode 89 of the first detector tube is connected through the primary of the intermediate frequency transformer 90 to a lead 91, which is connected to lead 67. The primary transformer 90 has its lower end connected to a grounded condenser 92. The secondary of transformer 90 is connected between lead 68 and grid 93 of the intermediate frequency amplifier. A tuning condenser 94 is connected between grid 93 and ground. Cathode 95 is connected to lead 77, which connects cathodes 64, 74 and 95, and leads to a tuning meter 96. The other terminal of meter 96 is connected through a bias resistance 97 to lead 268. Anode 98 of the intermediate frequency amplifier is connected through the primary of a transformer 99 to anode post 91 and thence to ground through a condenser 100. The secondary of transformer 99 is connected to grid 101 of a second detector and also to ground. A tuning condenser 102 is shunted across the secondary. Cathode 103 is grounded to a biasing resistance 104. Anode 105 of the second detector is connected to the primary of an audio-frequency transformer 106 to anode post 91 and to grounded condenser 107. The secondary of transformer 106 feeds audio-frequency to a suitable amplifier and translating means (not shown.)

A power supply of the usual type has its positive pole connected to terminal 201 of the voltage divider 202. Lead 67, supplying various anodes, is connected to the voltage divider at this point. The other end of the voltage divider is grounded. Lead 68, supplying potential to the grids of various tubes is connected through a resistance 269 to lead 268. Lead 268 is brought to point 208 on the voltage divider. Lead 88, connecting through the plate 87 of the oscillator tube, taps on point 250 of voltage divider 202. The various shield grids 251 of the radio-frequency and intermediate frequency amplifiers and first detectors are connected through lead

252 to a suitable point 253 on divider 202. Shield grid 255 is connected through a lead 256 to point 257 on divider 202.

Anode 270 of the A. V. C. tube is connected  
5 by lead 271 to lead 68 supplying potential  
to the R. F. grids. Grid 272 of this tube is  
connected through a regulating resistance 273  
to the cathode 103 of the second detector.  
10 Shield grid 274 is given a suitable potential  
by connecting it to a point 275 on the voltage  
divider. Cathode 276 of the A. V. C. tube is  
connected through a lead 277 to a slider 278  
operating on resistance 280. This latter  
15 resistance is connected from ground to a  
suitable point 281 on bridge resistance 282  
connected between points 201 and 208 on the  
voltage divider.

Inasmuch as the operation of this circuit is  
similar to that shown in Figure 2, no detailed  
20 explanation is necessary.

I claim:—

1. In a radio system of the type having a  
radio frequency amplifier, a power supply  
including a voltage divider with a poor regu-  
25 lation characteristic, and provided with a  
detector adapted to function over a substan-  
tial input voltage range, the combination of  
an automatic volume control circuit compris-  
ing a vacuum tube, connections from said  
30 power supply to said tube for energizing the  
latter, said connections including a resistance  
in the radio frequency grid circuit and a con-  
nection from the anode of said automatic  
volume control tube to the low side of said  
35 resistance, a connection from the grid of said  
automatic volume control tube to the cathode  
of said detector, a bridge resistance connect-  
ing two points on said voltage divider having  
opposite voltage regulation characteristics,  
40 an additional resistance connected between a  
point on said voltage divider and a point on  
said bridge resistance, said bridge resistance  
point being at a higher potential than said  
voltage divider point, and a connection from  
45 the cathode of said automatic volume control  
tube to a point on said additional resistance.

2. In a radio receiver of the type having  
a radio frequency amplifier, a power detector  
and a power supply including a voltage  
50 divider having a poor regulation character-  
istic and having a separate automatic volume  
control tube with circuit connections, where-  
by the grid bias of the radio frequency ampli-  
fier is a function of the space current through  
55 the automatic volume control tube, the com-  
bination of means for obtaining a predeter-  
mined automatic volume control character-  
istic comprising a bridge resistance connect-  
ing two points on said voltage divider having  
60 opposite load potential characteristics, where-  
by a neutral point on said bridge resistance  
exists where the potential is substantially  
constant with varying load during the nor-  
mal operation of the set, a second resistance  
65 connected to a point on said bridge resistance

in the neighborhood of the neutral point, the  
other end of said second resistance being  
connected to the voltage divider at a point  
near the low potential end thereof, and ad-  
justable means for connecting the cathode of  
70 said automatic volume control tube to a pre-  
determined portion of said second resistance.

3. In a radio receiver of the type having a  
radio frequency amplifier, a power detector  
75 and a power supply including a voltage di-  
vider having a poor regulation characteristic  
and having a separate automatic volume con-  
trol tube with circuit connections whereby  
the grid bias of the radio frequency ampli-  
fier is a function of the space current through  
80 the automatic volume control tube, the com-  
bination of a bridge resistance connected be-  
tween two points on said voltage divider hav-  
ing opposite voltage characteristics so that  
said bridge resistance has a neutral point  
85 thereon of substantially constant potential  
during normal load variations and connec-  
tions from the cathode of the automatic vol-  
ume control tube to said bridge resistance at  
a point in sufficient proximity to said neutral  
90 point to compensate for the regulation char-  
acteristic of the resistance in the automatic  
volume control cathode circuit and thus ob-  
tain a predetermined automatic volume con-  
95 trol characteristic.

4. In a radio receiver of the type having a  
radio frequency amplifier, a power detector  
and a power supply including a voltage di-  
100 divider having a poor regulation characteristic  
and having a separate automatic volume con-  
trol tube of the shield grid type, said tube  
having circuit connections whereby the grid  
bias of the radio frequency amplifier is a func-  
tion of the space current through the auto-  
105 matic volume control tube, the combination  
of means for obtaining a predetermined auto-  
matic volume control characteristic compris-  
ing a bridge resistance connecting two points  
having opposite voltage characteristics on  
110 said divider whereby a neutral point on said  
bridge resistance is formed, a second resis-  
tance having one end connected to a point  
on said divider in proximity to its low poten-  
tial end, means for connecting said automatic  
115 volume control cathode to a predetermined  
point on said second resistance, and means  
for connecting the other end of said second  
resistance to a point on said bridge resistance,  
said last point being so related to said neu-  
120 tral point that a predetermined degree of  
voltage regulation is introduced to compen-  
sate for the inherently poor regulation of the  
resistance in the automatic volume control  
cathode circuit and also in the shield grid  
125 circuit.

In testimony whereof he affixes his signa-  
130 ture.

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