

Feb. 26, 1946.

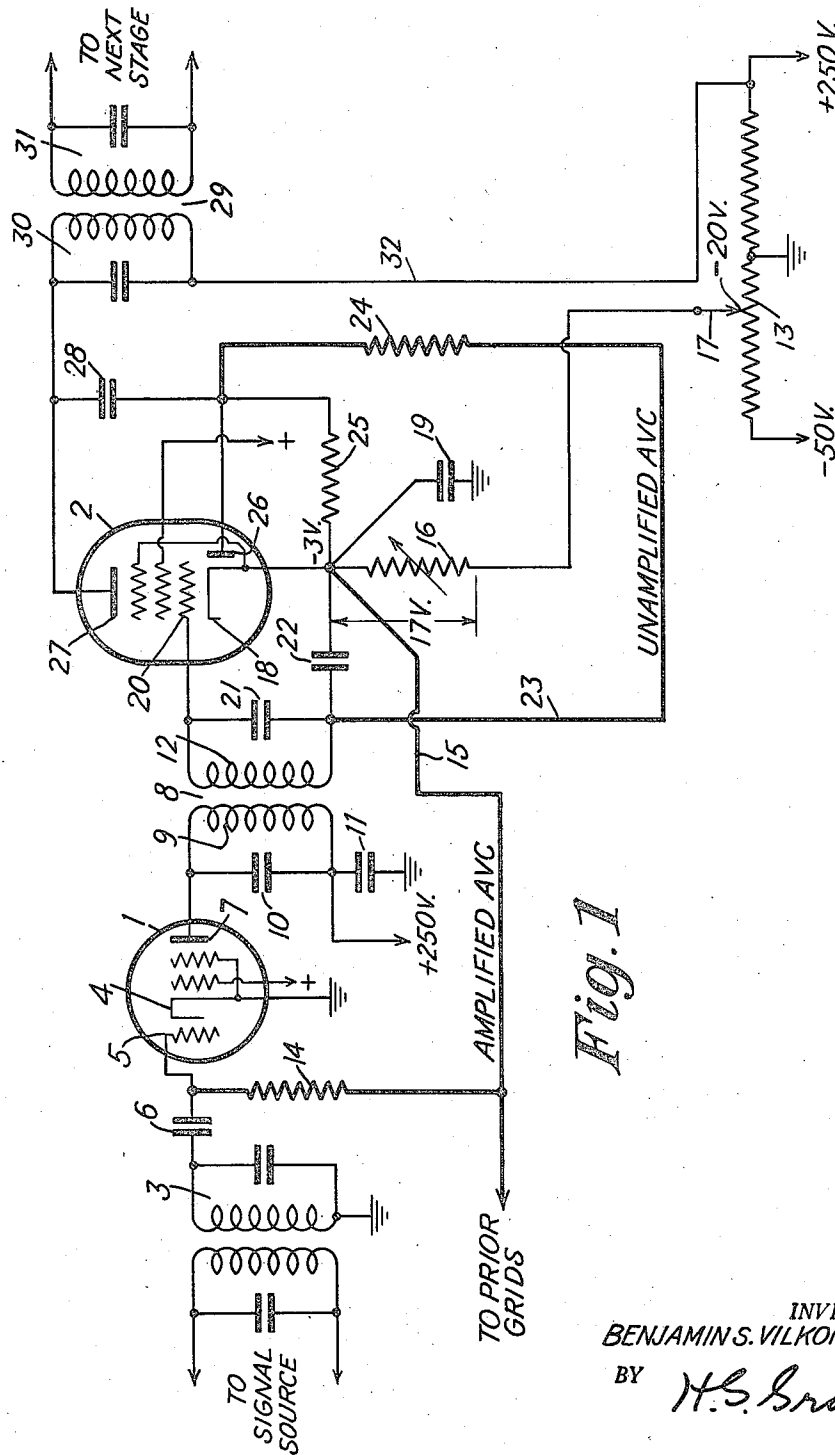
B. S. VILKOMERSON

2,395,770

AUTOMATIC GAIN CONTROL CIRCUIT

Filed July 19, 1944

2 Sheets-Sheet 1



Feb. 26, 1946.

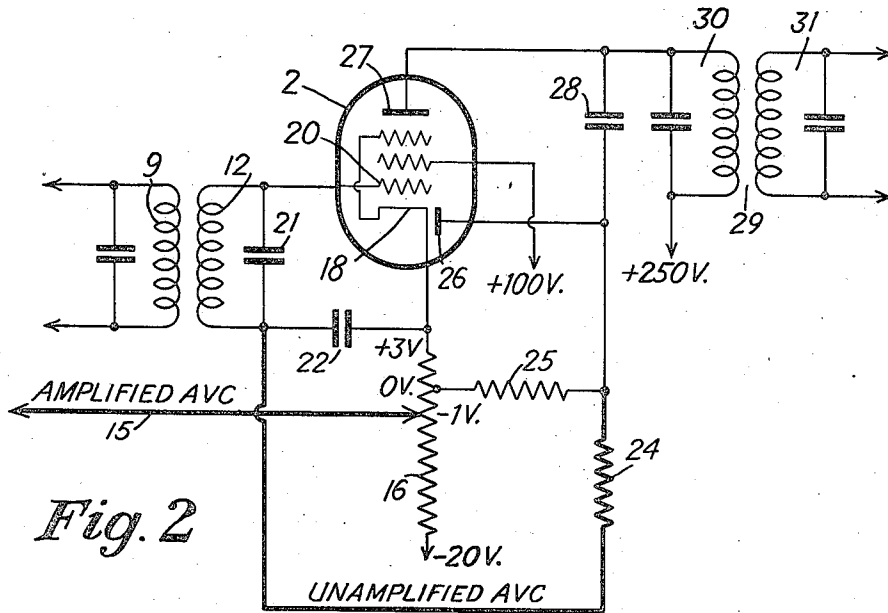
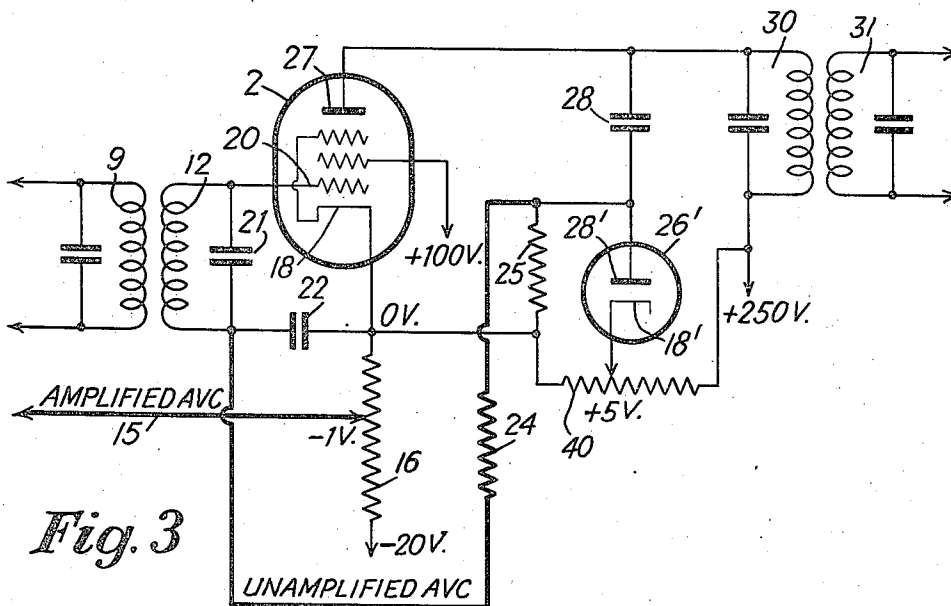
B. S. VILKOMERSON

2,395,770

AUTOMATIC GAIN CONTROL CIRCUIT

Filed July 19, 1944.

2 Sheets-Sheet 2



INVENTOR.
BENJAMIN S. VILKOMERSON

BY *H.S. Brewer*

ATTORNEY.

UNITED STATES PATENT OFFICE

2,395,770

AUTOMATIC GAIN CONTROL CIRCUIT

Benjamin S. Vilkomerson, Camden, N. J., assign-
or to Radio Corporation of America, a corpora-
tion of Delaware

Application July 19, 1944, Serial No. 545,614

4 Claims. (Cl. 179—171)

My present invention relates generally to automatic gain control circuits for wave amplifiers, and more specifically to improved automatic volume control (AVC) circuits for high frequency amplifiers.

There have been devised many circuits in the past for automatically regulating the gain of a wave amplifier in response to variations in wave amplitude. It has, furthermore, been appreciated that amplified AVC action is desirable, because of its relatively faster control over the gain of the controlled circuits. Accordingly, various arrangements have been proposed to amplify the AVC voltage prior to application to the control grids of the controlled amplifier stages. It is common practice in larger receivers to use only partial AVC, or no AVC, on the last I. F. amplifier (intermediate frequency) tube which drives the AVC diode. It is desirable that the gain in the last stage be kept fairly high under all conditions, so that the required AVC voltage may be obtained with a relatively small input voltage on the grid of the last I. F. amplifier stage. With a large signal input voltage, distortion is encountered due to "modulation rise," which is the effect of operating over the curved portion of the grid characteristic of the tube. The effectiveness of AVC on any tube in a cascaded amplifier depends on the number of tubes following it, since any change in gain, either positive or negative, is amplified by the succeeding stages. Therefore, applying amplified AVC to all but the last stage gives practically all the benefits of increased control, without the risk of distortion due to modulation rise in the last I. F. amplifier tube.

It is one of the main objects of my present invention to provide an improved amplified AVC circuit wherein an existing high frequency amplifier is assigned an additional function of amplifying AVC voltage without interfering with its normal signal amplifying function.

Another important object of my invention is to provide a signal amplifier tube with a cathode resistor across which is developed a signal-responsive voltage of opposite polarity to a fixed bias voltage; the resultant differential voltage being employed as the AVC bias for one or more prior signal amplifiers.

Another object of my invention is to provide a high frequency amplifier tube adapted to have unamplified delayed AVC bias applied to its signal grid, while amplified delayed AVC bias is developed across a cathode resistor of the amplifier tube for application to one or more preceding high frequency amplifier tubes.

Still other objects of my invention are to improve generally the efficiency and reliability of of AVC circuits, and to provide an AVC circuit of minimum components.

The novel features which I believe to be characteristic of my invention are set forth with 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 shows one embodiment of my invention;

Fig. 2 shows a modification employing delayed AVC; and,

Fig. 3 illustrates a further delayed AVC modification.

Referring now to the drawings, wherein like reference characters in the different figures denote similar circuit elements, there is shown in Fig. 1 a wave amplifier system embodying means for producing both unamplified and amplified AVC voltage in response to variations in intensity of applied wave energy. By way of specific illustration let it be assumed that high frequency signal waves, such as intelligence-modulated carrier waves, are amplified in a plurality of cascaded amplifier stages. It is to be clearly understood that the invention is applicable to receivers of amplitude modulated, frequency modulated or phase modulated carrier waves. Its operation being dependent on variations in carrier amplitude, the nature of the modulation of the carrier will not affect the AVC system disclosed herein. In order to maintain simplicity of description, let it be assumed that the amplifier tubes 1 and 2 of Fig. 1 are cascaded intermediate frequency (I. F.) amplifiers of any well-known form of superheterodyne receiver adapted to operate over the amplitude modulation broadcast reception range of 550 to 1700 kilocycles (kc.). Those skilled in the art of radio communication are fully aware of the details of construction of such a receiver. A suitable signal wave collector feeds the collected signal wave energy to one or more selective radio frequency amplifiers. Subsequent to selective amplification the selected modulated carrier energy is converted to the I. F. value, say 450 kc. by way of specific example. The I. F. energy is applied to the resonant input circuit 3 of amplifier tube 1.

The tube 1 is specifically illustrated as being a

pentode type of tube. However, any other type may be utilized, so long as its cathode 4 is directly grounded, and its signal grid 5 is coupled to the high alternating potential side of input circuit 3 by direct current blocking condenser 6. The low potential side of circuit 3 is directly returned to ground. The plate 7 of tube 1 is connected to a point of suitable positive direct current potential, say +250 volts, through the primary winding 9 of I. F. coupling transformer 8. The winding 9 is shunted by tuning condenser 10. I. F. bypass condenser 11 returning the low potential side of tuned circuit 9, 10 to the grounded cathode.

The source of direct current voltage for energizing the amplifier elements is represented as a typical bleeder resistor 13 whose opposite ends are at +250 and -50 volts relative to its grounded intermediate tap. In this way a wide range of positive and negative voltages may be provided through the receiver system. Such power supply potentiometers are too well-known to require further description. The plate 7 may be connected to the +250 volts point of voltage supply resistor 13.

The signal grid 5 of tube 1 is provided with a normal, or no-signal, negative bias of a predetermined magnitude by connecting it to a suitable negative voltage point on resistor 13 over the path consisting of filter resistor 14, lead 15, resistor 16 and adjustable slider 17. Merely by way of illustration, the slider 17 is shown adjusted to a point on the resistor 13 which is at approximately -20 volts relative to the ground point. The resistor 16 is arranged in the space current path of amplifier tube 2, and, therefore, develops across itself a direct current voltage. Since the signal grid 5 of tube 1 is connected to the cathode end of resistor 16, it follows that the normal bias of grid 5 will be the differential voltage of the drop across resistor 16 and the potential of the point on resistor 13 to which slider 17 is adjusted.

The amplifier 2 is shown as of the type comprising a pentode amplifier section and a separate diode section. Both sections of the tube use the common cathode 18. This cathode may be directly or indirectly heated. The cathode 18 is connected to ground for signal currents by an I. F. bypass condenser 19. The signal grid 20 of tube 2 is connected to the high alternating potential side of the parallel resonant circuit 12, 21, while the low potential side of the circuit is connected to the cathode 18 by the I. F. bypass condenser 22. The low potential side of resonant circuit 12, 21 is additionally connected to slider 17 through a path consisting of lead 23, alternating current filter resistor 24, diode load resistor 25 and cathode resistor 16. It will, therefore, be seen that the signal grid 20 has a normal no-signal bias which is the same as that of cathode 18. In other words, in the absence of received signal energy the signal grid is at the same potential as the cathode 18, and both of these electrodes are at a common direct current potential which is equal to the difference between the voltage drop across resistor 16 and the point on resistor 13 to which slider 17 is connected.

The diode section of tube 2 consists of the cathode 18 and the auxiliary anode 26 located adjacent the cathode, the anode 26 being out of the main electron stream which flows through the grids to the plate 27. The resistor 25, being connected between cathode 18 and anode 26, functions as the load resistor for the diode rectifier.

The condenser 28, which has a low impedance for I. F. currents, is connected from plate 27 to diode anode 26. Accordingly, I. F. signal currents amplified in the pentode section of tube 2 are impressed upon the diode rectifier 18, 26 for rectification.

The I. F. transformer 29 has its primary and secondary circuits 30 and 31 respectively tuned to the operating I. F. value. The high alternating potential side of primary circuit 30 is connected to plate 27, while the low potential side of circuit 30 is connected by lead 32 to the +250 volts point of the voltage supply resistor. The secondary circuit 31 may be connected to any following I. F. amplifier, or to a demodulator.

It will be understood that each of the resonant selector circuits between the signal source and circuit 31 is tuned to the operating I. F. value. Furthermore, the successive pairs of coupled resonant circuits are coupled to provide substantially band pass characteristics in order to provide efficient transfer of the modulated carrier wave energy. Assuming that it is desirable to maintain a substantially constant carrier amplitude at the network following circuit 31, the function of the AVC circuit is to vary the gain of each of the amplifiers 1 and 2 so as to prevent variations in carrier amplitude at the signal source from being repeated, or carried through to the network subsequent to circuit 31. It is well recognized that reception from stations at different distances and powers, and fading or similar phenomena, cause substantially wide variations in carrier amplitude at the signal collector of the receiving system.

Assuming that signals are being received and that such signals are successively amplified in the cascaded amplifier stages, the amplified signal energy is applied to the rectifier 18, 26 for developing across resistor 25 a rectified voltage whose magnitude is proportional to the intensity of the carrier. This rectified voltage is applied over lead 23 to the signal grid 20 of tube 2 in a polarity sense to bias the grid 20 negatively relative to the cathode 18. Resistor 24 and condenser 22 have their magnitudes so chosen as to provide a filter whose time constant is relatively long whereby only the relatively slow variations in carrier amplitude will vary the potential of grid 20. In other words resistor 24 and condenser 22 filter out all modulation currents, and a purely direct current voltage is applied to grid 20. Resistor 14 and condenser 6 may, also, function as a time constant network for the amplified AVC bias.

The rectified voltage applied to grid 20 is unamplified. In the absence of received energy the gain of tube 2 is a maximum, since there is zero bias so far as the grid 20 is concerned. Tube 1 is, also, at maximum gain for the no-signal state, since its grid 5 has a minimum negative bias with respect to its grounded cathode 4. Let it be assumed that the resistor 16, which may be adjustable as denoted by the arrow through the resistor, has been adjusted to a value of about 2000 ohms. Let it be assumed, further, that in the no-signal condition there occurs a voltage drop of 17 volts across resistor 16. It follows, therefore, that the cathode end of resistor 16 is effectively -3 volts with respect to ground. Since grid 5 is connected by lead 15 to the cathode end of resistor 16, it will be seen that grid 5 has a normal -3 volts bias with respect to grounded cathode 4.

As signal energy is received, and as rectified voltage is developed across resistor 25, the bias of grid 20 increases in a negative sense since the

anode end of resistor 25 becomes increasingly negative with respect to cathode 18 as the signal intensity increases. This results in a reduction in the space current flow through resistor 16. Hence, the voltage drop across resistor 16 decreases. It follows, therefore, that the cathode end of resistor 16 becomes increasingly negative, since its potential is equal to the difference between -20 volts and the voltage across resistor 16. Accordingly, the bias of grid 5 becomes increasingly negative and the gain of tube 1 is reduced, but at a faster rate and to a greater extent than the gain reduction of tube 2. It is desirable to reduce the gain of tube 1 by amplified AVC voltage, because it is important to provide a greater degree of control at the amplifier stages closer to the signal collector device. It will be understood that the amplified AVC bias may be applied to the signal grids of one or more of the amplifiers preceding tube 1. It will, of course, be recognized that amplified AVC action is secured, because the rectified voltage developed across resistor 25 is amplified in the pentode section of tube 2. Hence, the pentode section of tube 2 not only acts as an I. F. amplifier stage, but functions simultaneously as a direct current voltage amplifier. It will be recognized that the slider 17, or the variable resistor 16, may be employed for manual adjustment of the initial gain of each of tubes 1 and 2.

The rate of rise of signal output with carrier input intensity is always less for amplified AVC than for unamplified AVC. This results in a more uniform output characteristic, but also causes reduced gain at low signal levels unless a delay voltage is used. The delay voltage can be so chosen that for weak input signals the full gain of the amplifier 2 is obtained, while for signals whose intensity is above the delay voltage the amplified AVC gives almost flat response. It will be seen that for the same output signal level, more delay is required with amplified AVC.

In Fig. 2 I have shown a simple arrangement for embodying delay action in the AVC system of Fig. 1. It will be noted in Fig. 2 that resistor 16 is given a value of resistance such that the space current of the pentode section of tube 2 causes a voltage drop of several volts in excess of the bias voltage so that the cathode 18 is, for example, at +3 volts with respect to the grounded tap on resistor 13. The diode load resistor 25 returns to a point on resistor 16 which is at zero volts (D. C.) only when no signal is present. The zero volts point on resistor 16 must go negative to supply AVC voltage in the presence of a signal. Therefore, anode 26 is biased -3 volts relative to cathode 18. Hence, no rectified voltage will be developed across resistor 25 until the peak value of the signal voltage at anode 26 exceeds the -3 volts bias.

The lead 15, which is the amplified AVC lead, is connected to a point on resistor 16 which is at -1 volt with respect to the zero volts point on resistor 16. Accordingly, in the no-signal state the signal grid 5 (see Fig. 1) will have a normal negative bias of -1 volt. However, upon the signal voltage exceeding the delay bias on diode 18, 26 the signal grid 20 will be negatively biased to an extent sufficient to reduce the space current flow through resistor 16 thereby rendering the point on resistor 16 to which lead 15 is connected more negative. A limitation of the arrangement of Fig. 2 is that the initial grid potential of tube 2 will be +3 volts, or whatever the delay voltage is.

In Fig. 3 I have shown a modification of the

circuit of Fig. 1 wherein zero initial bias is employed for tube 2, while delay bias is secured for the AVC diode. In this modification there is required a separate diode 26' having a cathode 18' separated from the amplifier cathode 18. More specifically, the diode 26' has its anode 28' connected to the upper end of resistor 25, while the cathode 18' is adjustably connected to a suitable point of positive potential of a high resistance 40. The resistor 40 is connected between the cathode 18 and the +250 volts lead which supplies plate 27. In this way it is possible to apply a desirable amount of delay bias to the anode 28' of the diode 26'. Merely by way of illustration, it is shown in Fig. 3 that the cathode tap of diode 26' is adjusted to a point on resistor 40 such that normally the cathode 18' is +5 volts with respect to the anode 28' whose normal direct current potential is zero volts. Upon the signal voltage overcoming the -5 volts delay bias, rectified voltage will appear across resistor 25.

In the absence of signals control grid 20 is at zero volts, because the grid 20 is connected to the cathode 18 through resistor 25. Again, as in Fig. 2, the cathode end of resistor 16 is at zero volts (D. C.) only when no signal is present, and must go negative to supply AVC voltage in the presence of received signal energy. The lead 15 is again connected to a point on resistor 16 such that a normal bias of -1 volt is applied to the signal grids of the amplifier tubes preceding tube 2. Accordingly, when the unamplified AVC bias is applied to grid 20 the space current flow through resistor 16 will decrease, and thereby cause amplified AVC bias to be produced.

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 organizations shown and described, but that many modifications may be made without departing from the scope of my invention.

What I claim is:

1. In combination with a signal amplifier tube provided with input and output circuits, said tube including at least a cathode, signal grid and plate, a resistive impedance connected between the cathode and a point of negative potential, a rectifier device including a signal input connection from said amplifier output circuit, a load impedance in circuit with said rectifier device, said load being included in a path between said signal grid and the cathode end of said resistive impedance, at least one amplifier tube preceding said first tube and including at least a signal grid, cathode and output electrode, and voltage control connections from the signal grid of said preceding tube and the cathode end of said resistive impedance whereby the effective voltage applied to said preceding tube signal grid is the resultant differential of said negative potential and the voltage across said resistive impedance.

2. In combination, a plurality of cascaded signal transmission tubes, a biasing circuit for the signal grid of a later one of said tubes, said biasing circuit including a source of constant negative voltage and source of positive voltage, means responsive to signal intensity variation for varying the space current of the later tube thereby to vary the magnitude of said source of positive voltage, and means, responsive to the resultant differential of said constant negative voltage and variable positive voltage, for regulating the bias of the signal grid of at least one tube prior to said later tube.

3. In combination with a signal amplifier tube provided with input and output circuits, said tube including at least a cathode, signal grid and plate, a resistive impedance connected between the cathode and a point of negative potential, a rectifier device including a signal input connection from said amplifier output circuit, said rectifier consisting of an auxiliary anode and said cathode, a load impedance in circuit with said rectifier device, said load being included in a path between said signal grid and the cathode end of said resistive impedance, at least one amplifier tube preceding said first tube and including at least a signal grid cathode and output electrode, and a voltage control connection from the signal grid of said preceding tube and a point of negative potential of said resistive impedance whereby

the effective voltage applied to said preceding tube signal grid is the resultant differential of said negative potential and the voltage at said point of said resistive impedance.

5 4. In combination with a plurality of cascaded signal transmission tubes, a biasing circuit including a source of constant negative voltage and source of variable positive voltage, means responsive to signal intensity variation for varying the space current of the later tube thereby to vary the magnitude of said source of positive voltage, and means, responsive to the resultant differential of said constant negative voltage and variable positive voltage above a predetermined delay bias for regulating the bias of the signal grid of at least one tube prior to said later tube.

10 15 BENJAMIN S. VILKOMERSON.