Sept. 12, 1939. W. R. KOCH 2,172,476

VOLTAGE DOUBLING AUTOMATIC VOLUME CONTROL CIRCUIT

Filed April 6, 1936

Fig. 1

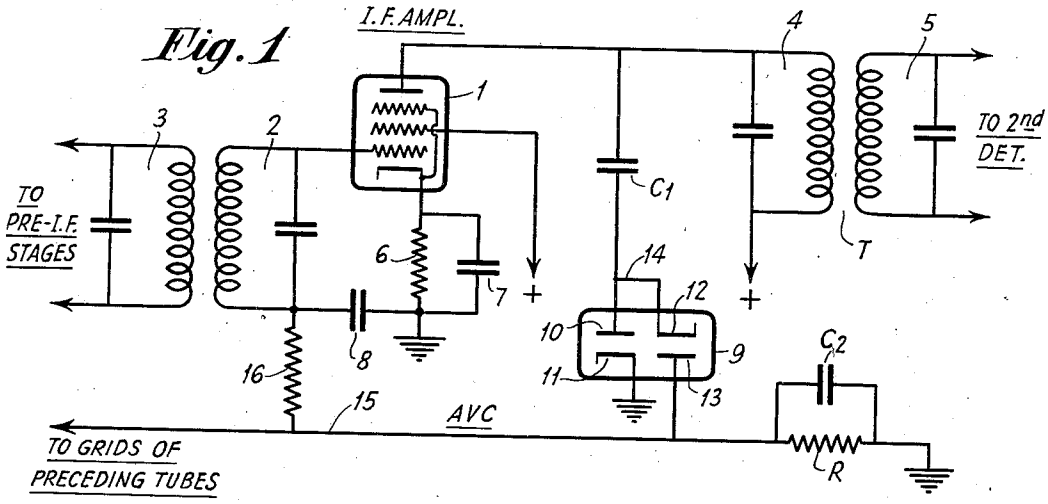
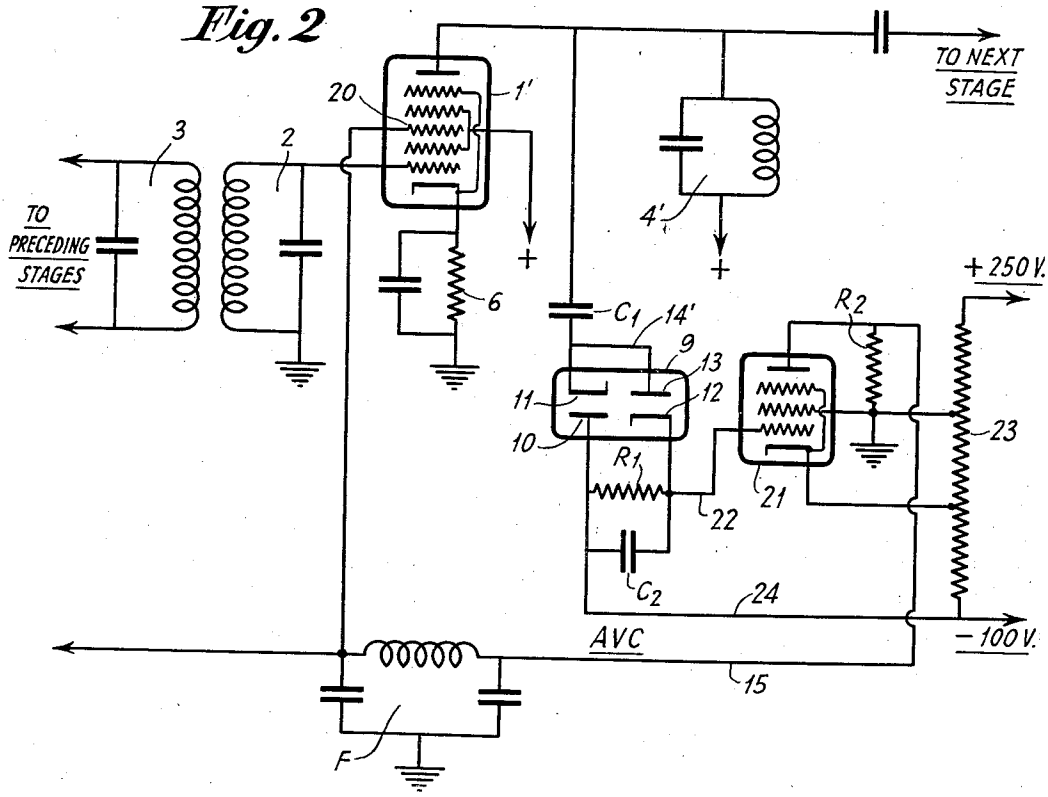


Fig. 2



INVENTOR
WINFIELD R. KOCH
BY H. S. Knox
ATTORNEY

Patented Sept. 12, 1939 2,172,476

UNITED STATES PATENT OFFICE

2,172,476

VOLTAGE DOUBLING AUTOMATIC VOLUME CONTROL CIRCUIT

Winfield R. Koch, Camden, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application April 6, 1936, Serial No. 72,861

2 Claims. (Cl. 179—171)

My present invention relates to automatic volume control circuits, and more particularly to improved voltage doubling networks adapted for use in connection with automatic volume control arrangements for high frequency signaling systems.

One of the main objects of my present invention is to provide a voltage doubling signal rectifier network wherein the rectified output of the network includes a minimum of high frequency component, and the network being essentially characterized by its inclusion of a pair of diode circuits functioning on successive half cycles of an impressed signal wave, one of the diode circuits functioning to produce a direct current voltage equal to the peak signal voltage during one half cycle, and the other diode circuit being electrically associated with the first diode circuit in such a manner as to produce in its output a direct current voltage which is double the peak signal voltage and of the same polarity as the direct current voltage produced by the first diode circuit.

Another important object of the present invention is to provide an automatic volume control circuit which utilizes a voltage doubling rectifier network as a source of gain control voltage, and the doubling network comprising a diode having one electrode thereof capacitatively coupled to a source of impressed signal waves, and its other electrode grounded; a second diode provided in shunt with the first diode, one of the electrode circuits of the second diode including a load impedance for developing a direct current voltage which is double the peak signal voltage.

Another object of the present invention is to provide a voltage doubling rectifier network for an automatic volume control circuit of a radio receiving system, wherein the direct current voltage which is produced by rectification of impressed signal waves is amplified in a direct current amplifier, and the output of the amplifier is used for varying the gain of at least one of the signal transmission tubes of the receiving system.

Still other objects of the invention are to improve generally the efficiency and simplicity of automatic volume control circuits, and more especially to provide voltage doubling networks adapted for automatic volume control arrangements in radio receivers which will not only be reliable and efficient in operation, but be capable of being economically assembled and manufactured in receivers.

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 drawing in which I have indicated diagrammatically two circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 diagrammatically shows a portion of a radio receiving system embodying one form of the present invention,

Fig. 2 shows another embodiment of the present invention.

Referring now to the accompanying drawing, wherein like reference characters in the two figures designate similar circuit elements, attention is first drawn to the fact that the present invention is directed to an improved form of automatic volume control arrangement for radio receiving systems, and wherein the volume control arrangement is of the voltage doubling type. In general, such voltage doubler networks have been utilized in the past for rectification of high frequency signals, and even for the purpose of providing direct current voltage for automatic gain control of high frequency transmission tubes. Since the present invention resides in the improvement of the voltage doubler network, and its associated gain control circuits, only that portion of the receiving system which is directly coupled to the voltage doubler network is shown in the drawing.

While the present invention is adapted for use in connection with radio receivers of various types, the present description is directed towards the showing of a high frequency signal receiving system of the superheterodyne type. As is well known to those skilled in the art, such a receiving system usually embodies a means for collecting high frequency carrier modulated signals, and the collected signals are impressed upon one or more tunable high-frequency signal amplifiers. It is clearly to be understood that the present invention may be employed in connection with signals in the broadcast band (550 to 1500 k. c.) or it may be used in connection with the reception of signals in the television band (signals of the order of 3 to 6 meters). In any case, the amplified high frequency signals are impressed upon a first detector, or mixer, network, and heterodyned with locally produced oscillations. The local oscillator may comprise a tube independent of the first detector tube, or

the local oscillator network may be associated with a network of the so-called pentagrid converter type. Either of these types of mixer circuits are well known, and need not be described further.

The I. F. output of the mixer tube may have a frequency value of the order of 175 k. c. if signals in the broadcast band are being received, and if signals in the television band are being received, the frequency value may be of the order of 30 meters. It is to be clearly understood that one or more stages of I. F. amplification may be utilized, and the numeral 1 is to be understood as designating the last I. F. amplifier tube. This tube has its input grid and and cathode coupled across a resonant input circuit 2, the latter being tuned to the operating I. F. The network 2 is reactively coupled to a resonant network 3, also tuned to the operating I. F., which is to be understood as being disposed in the output of the mixer tube, or in the plate circuit of the next preceding I. F. amplifier tube.

The plate circuit of the I. F. amplifier 1 includes a resonant network 4, tuned to the operating I. F., and the network 4 is reactively coupled to the I. F. tuned network 5. The latter may be coupled to a second detector tube, or demodulator, and it is to be understood that this demodulator may be of the diode type, or of any other type of detector tube known to those skilled in the art. The demodulated output of the detector may then be amplified in one, or more, stages of audio frequency amplification, and the amplified audio output may be reproduced in any desired fashion.

The cathode of I. F. amplifier 1 is connected to ground through the customary biasing resistor 6, the latter being by-passed for I. F. currents by the condenser 7, and the blocking condenser 8 is connected between the low alternating potential side of input network 2 and the grounded side of bias resistor 6. Of course, the magnitude of resistor 6 is such as to provide the normal operating bias for the signal grid of amplifier 1. It is to be understood that the circuits associated with the tubes preceding the amplifier 1 will, in general, be constructed in a fashion similar to the circuits of amplifier 1, assuming that the function of such preceding tubes is to amplify high frequency signal energy.

The automatic volume control arrangement comprises an electron discharge tube 9 of the 6H6 type. This type of tube is well known to those skilled in the art, and comprises a pair of diodes whose electrodes are disposed within a common tube envelope. One of the diodes, including anode 10 and cathode 11, has its anode 10 connected to the plate side of network 4 through an I. F. by-pass condenser C_1, whereas the cathode 11 is grounded. The other diode of tube 9, including the cathode 12 and anode 13, has its cathode 12 connected by lead 14 to the anode side of condenser C_1. The diode anode 13 is connected to ground through a relatively large resistor R, the I. F. by-pass condenser C_2 being connected across the resistor R. The anode side of resistor R is connected to the grid side of condenser 8 through connection 15, the latter including in series therewith the filter resistor 16.

The connection 15 is designated by the letters "AVC" to denote that this connection is the automatic volume control connection from the voltage-doubling signal rectifier network. As shown in Fig. 1, the connection 15 may be made to the gain control electrodes, such as the signal grids, of such of the tubes preceding amplifier 1 whose gain it is desired to regulate automatically. In explaining the automatic volume control action of the arrangement shown in Fig. 1, it is first pointed out that no current flows through the diode 12—13 during the positive half cycle of I. F. signals transmitted to the primary network 4 of the I. F. coupling transformer T. This will be clear when it is realized that during the positive half cycle the cathode 12 will be positive with respect to the anode 13, and, therefore, the space between electrodes 12 and 13 will not be conductive. However, during this positive half cycle, electrons will flow from ground through the diode 10—11 to the condenser C_1.

In other words, during the positive half cycle of the I. F. signals, the anode side of condenser C_1 will be electrostatically charged negative with respect to the opposite side of the condenser. The side of condenser C_1 connected to anode 10 will have a charge on it equal to the peak voltage of the I. F. signal. Now, when the applied I. F. voltage reverses, that is during the negative half cycle, the diode 12—13 becomes conductive; whereas the diode 10—11 is non-conductive. Since the cathode 12 is connected, through connection 14, to the negative side of condenser C_1, there will be applied to the electrodes 12—13, and across condenser C_2, the voltage across condenser C_1 plus the negative half of the I. F. signal voltage.

After several cycles of operation, the condenser C_2 will be charged up to twice the peak I. F. signal voltage, provided the resistor R is large. It will, therefore, be seen that the function of the condenser C_2 is to develop for AVC purposes a negative voltage which is double that of the I. F. signal peak value. As the signal amplitude increases, the AVC voltage applied to the signal grid of the amplifier 1, and the other controlled tubes, through the connection 15 increases, and the gain of each of the controlled signal transmission tubes is therefore reduced. Of course, when no signals, or signals of small amplitude, are received, the controlled tubes are operating at maximum amplification, since in those cases the negative voltage at the anode side of resistor R is at a minimum.

It will further be observed that since the voltage-doubler rectifier network is operated from the primary of the I. F. transformer T, rather than from the secondary, the signal voltage available is greater than that available at the secondary network 5, particularly when the receiver is slightly off tune, because the selectivity up to the primary network 4 is less. By using the voltage doubling system shown in Fig. 1 the load resistor R is by-passed, so that separating the I. F. and direct currents is much easier, and twice the direct current voltage is developed at resistor R, which increases the efficacy and range of the AVC action. Those skilled in the art will readily understand that instead of utilizing a separate demodulator, the audio component of rectified I. F. signals may be tapped off from the load resistor R. Furthermore, one or more stages of I. F. amplification may be employed in the channel feeding the rectifier tube 9 thereby furnishing less selectivity for AVC operation than for demodulation, and at the same time furnishing greater I. F. voltage for the voltage-doubler rectifier tube.

In Fig. 2 there is shown a modification of the

arrangement disclosed in Fig. 1, and wherein the numeral 1' denotes an I. F. amplifier tube which includes five grids between the plate and cathode. The I. F. input circuit is connected between the signal grid and cathode, a special gain control grid 20 being disposed between a pair of positive screen grids. The tube 1' may be of the 6L7 type, if desired, and the function of the grid 20 is to regulate the gain of tube 1'. The low alternating potential side of network 2 is grounded. It, therefore, is directly connected to the ground side of bias resistor 6 whereby the normal operating bias across resistor 6 is impressed upon the signal grid, which is the number one grid, of amplifier 1'.

The plate circuit of amplifier 1' includes the I. F. tuned network 4', and the high alternating potential side of network 4' may be coupled to additional stages of I. F. amplification, or, in the alternative, to the demodulator of the receiving system. The double diode rectifier 9, in this modification, has the cathode 11 connected to the plate side of I. F. output network 4' through condenser C_1. The diode anode 10 is connected to the negative side of load resistor R_1, the by-pass condenser C_2 being connected in shunt across the resistor. The diode anode 13 is connected by connection 14' to the cathode 11, whereas diode cathode 12 is connected to the grid side of resistor R_1.

The direct current voltage developed across resistor R_1 is amplified in a direct current amplifier 21, and this is accomplished by connecting the input grid to the cathode side of resistor R_1 through a connection 22. The voltage supply bleeder 23 has an intermediate point thereof grounded, one side thereof being shown at a positive potential of 250 volts, whereas the other end may be established at a negative potential of 100 volts. The negative terminal of bleeder resistor 23 is connected by lead 24 to the negative side of resistor R_1, and the cathode of amplifier 21 is connected to a point on bleeder resistor 23 which is intermediate the ground point and the negative potential side thereof. The plate of amplifier 21 is connected through resistor R_2 to the intermediate ground point on bleeder resistor 23, and the screen grid electrode of amplifier 21 may, also, be connected to the ground side of resistor R_2. The AVC lead 15 is connected between the gain control electrode 20 and the plate side of resistor R_2, and a filter network F is inserted in the gain control connection 15 in order to prevent the transmission of any I. F. currents to the gain control electrodes.

By means of the modified arrangement shown in Fig. 2, not only is the double diode rectifier 9 capacitatively coupled to the high alternating potential side of the I. F. output network 4', but the AVC action is amplified and faster acting. It is, also, to be noted that there is a delay in the AVC action until the signal amplitude transmitted through the receiver exceeds a predetermined minimum carrier amplitude. The input grid of amplifier 21 is connected to the cathode side of resistor R_1 so that an increasingly positive voltage across R_1 results in an increasingly negative voltage at the plate side of resistor R_2.

In explaining the operation of the AVC action occurring in the arrangement of Fig. 2, it will be observed that on the negative half cycle of the I. F. signal swing, the diode 11—10 is conductive, whereas the diode 13—12 is non-conductive. This means that during the negative half cycle of the I. F. signal swing, the cathode side of condenser C_1 is positive with respect to the other side thereof. Conversely, during the positive half cycle of the signal swing the diode 11—10 is non-conductive, and the diode 13—12 becomes conductive, with the result that the condenser C_2 is charged and develops double the peak I. F. signal voltage. This occurs by virtue of the fact that the anode 13 is connected to the positive side of condenser C_1. Hence, it will be seen that as the I. F. signal amplitude increases, the cathode side of resistor R_1 increases in positive voltage, with the result that the space current flow through resistor R_2 increases. This necessarily means that the plate side of resistor R_2 increases in negative potential with respect to ground, thereby increasing the negative voltage on the gain control electrode 20 of amplifier 1'.

The delay action in the AVC is secured by virtue of the initial bias voltage, derived from bleeder resistor 23, which is provided between the input electrodes of amplifier 21. When the positive voltage transmitted through lead 22, overcomes the initial negative bias on the input grid of amplifier 21, then an increase in space current flow through resistor R_2 follows and the AVC action commences. By applying the AVC voltage to a special grid of the amplifier 1', the AVC action is made faster. Furthermore, the I. F. circuit 2 feeding the signal grid of control tube 1' is not detuned by the change in capacity of the tube when the electrode 20 is biased off.

In general, it will be seen that the signal rectifier for AVC voltage production is a voltage-doubler network provided with one diode circuit having a condenser in series with the space current path of the diode, and which condenser is charged to the peak signal voltage during one half cycle of the signal swing. A second diode circuit is provided, and has one of its electrodes connected to the charged condenser, and a load impedance is connected to the other electrode of the second diode circuit. The electrodes of the two diodes connected in common to the charged condenser are of opposite polarity during each half cycle of the impressed signal waves. This results in the production across the load impedance of a direct current which is double the peak signal voltage. The direct current voltage produced in this manner is utilized for gain control, and its magnitude varies in accordance with the variation in I. F. carrier amplitude.

While I have indicated and described two 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. In combination with a signal transmission tube adapted to transmit modulated carrier energy of a predetermined frequency, an automatic gain control arrangement characterized by the inclusion therein of a rectifier network, said network including at least two diodes connected in shunt relation, a condenser connecting the output circuit of said transmission tube to a junction point of said shunt-connected diodes, an impedance disposed in series with the space current paths of both of the diodes and connected solely between a pair of dissimilar electrodes of said two diodes, a connection between a point on said impedance and a gain control electrode of said transmission tube, said connection including an

electron discharge tube having its input electrodes connected across said impedance, a second impedance disposed in the space current path of said last named tube, and a connection between a point of negative direct current potential on the second impedance and a transmission tube gain control electrode other than the signal input electrode thereof.

2. In an alternating current circuit, a source of alternating current, a path between the source and a point of relatively fixed potential, said path including a capacitor in series with the space current path of a diode, a second path connected between said source and said point, the second path including said capacitor in series with the space current path of a reversed second diode and a load impedance, said impedance being in series relation with the space current paths of both diodes, there being developed across said impedance a direct current voltage which is double the peak alternating voltage from said source, and means for reversing the polarity of said direct current voltage and other means, responsive to the reversed voltage, for controlling the current amplitude at said source.

WINFIELD R. KOCH.