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R. D. BROWN, JR

2,086,465

AUTOMATIC VOLUME CONTROL SYSTEM

Filed March 3, 1932

Fig. 1.

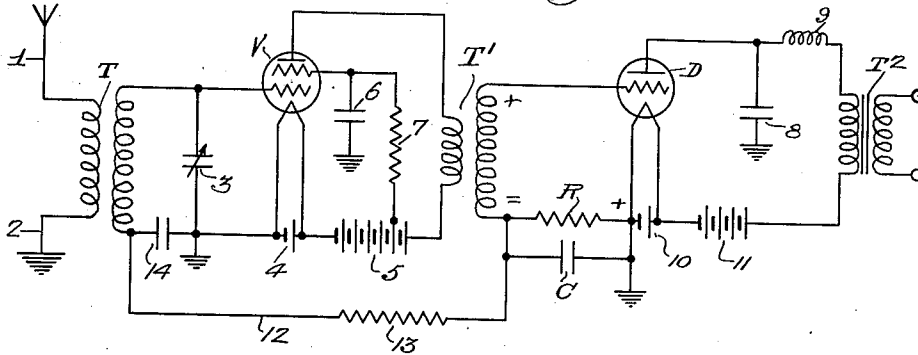


Fig. 2

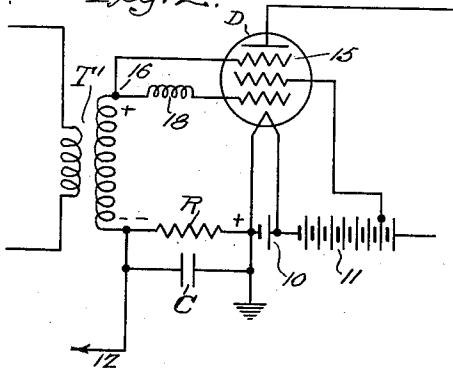


Fig. 3.

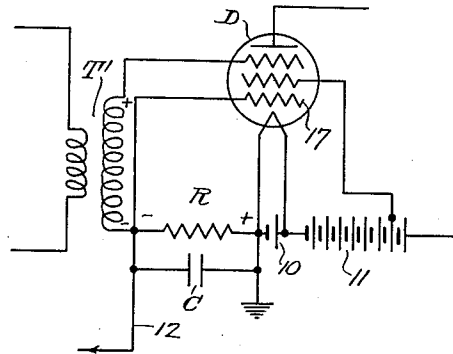


Fig. 4.

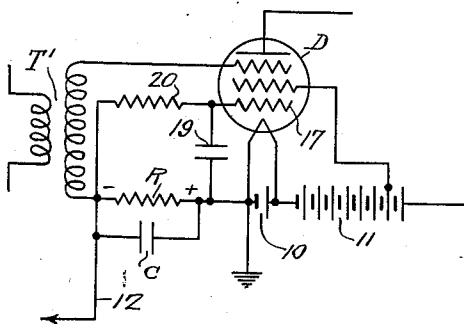
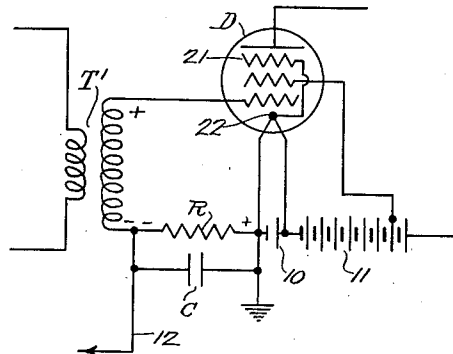


Fig. 5.



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UNITED STATES PATENT OFFICE

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AUTOMATIC VOLUME CONTROL SYSTEM

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12 Claims. (Cl. 250—20)

This invention relates to carrier waves receiving systems and has particular reference to the automatic control of the volume of the output of such systems. The present invention is related to the subject matter of co-pending application of David G. McCaa and Reynolds D. Brown, Jr., Serial No. 405,964, filed Nov. 9, 1929, Patent No. 2,061,710, November 24, 1936 and that of co-pending application of Reynolds D. Brown, Jr., Serial No. 412,163, filed Dec. 6, 1929, Patent No. 1,988,370, January 15, 1935.

An object of the invention is to provide means for limiting the output volume of a system to a certain predetermined level regardless of increases in the amplitude of the carrier wave input to the system.

Another object of the invention is to provide means for so controlling the output volume of a radio-receiving system that strong carrier waves are reduced to a predetermined level while carrier waves which are weaker than that level will be only slightly affected.

A further and more specific object of the invention is to provide a system wherein a uni-directional control voltage corresponding in amplitude to the amplitude of the carrier voltage is derived from the input or grid-cathode circuit of a thermionic or vacuum tube detector of the system. Otherwise stated, the invention contemplates the use of the grid rectification current of the detector to derive the uni-directional control voltage, such voltage being applied directly to the control grid or grids of one or more of the radio frequency amplifiers to thereby control the efficiency of such amplifiers.

A further object of the invention is to provide a system wherein a detector circuit having high amplification and overload characteristics is utilized as a source of control energy for controlling the radio frequency amplifiers.

A still further object of the invention is to provide a system wherein grid-leak detection is made possible with a screen grid tube and the volume control energy is derived from the rectification action of the control grid of the detector. By means of the invention, the high audio amplification afforded by grid-leak detection and also by the use of a screen grid tube, as well as other advantages, are had.

A still further object of the invention is to provide a novel system wherein a single screen grid tube of special construction is made to serve as a rectifier of high frequency alternating currents and also as a sensitive amplifier of audio fre-

quency currents having useful overload characteristics.

A clear understanding of the invention may be had from the following detailed description and the accompanying drawing, wherein there is illustrated a specific embodiment of the invention. In the drawing:

Fig. 1 is a schematic circuit diagram of a simple receiving system embodying certain features of the invention; and

Figs. 2 to 5 are similar diagrams of modifications.

Referring to Fig. 1 of the drawing, there is illustrated a receiving system having the usual antenna 1 connected through the primary winding of an input transformer T to ground as at 2. Transformer T serves to couple the antenna circuit to a tuned radio frequency amplifier stage comprising a radio frequency vacuum tube amplifier V. The usual tuning condenser 3 is connected across the output of transformer T, and the usual energizing sources, herein illustrated as batteries 4 and 5, are provided for amplifier V.

In the present illustration, a single stage of radio frequency amplification is shown but this is merely for the purposes of illustration and clarity, it being understood that any desired number of radio frequency or intermediate frequency amplifying stages may be used. The stage or stages of high frequency amplification may take any conventional form and may include as elements thereof any desired type of potential controlled amplifying device. In the present illustration, the single radio frequency amplifying stage is shown as including a screen grid tube which comprises, as is well known, a shielding grid in addition to the usual cathode, control grid, and anode. Radio frequency by-pass condenser 6 and filter resistance 7 are included in the circuit of the shielding grid in the usual manner.

A second radio frequency transformer T₁ serves to couple the amplifying stage just described to the input of a vacuum tube detector D of the usual type. While shown herein as a three-electrode tube, detector D may take the form of any conventional tube which may be utilized for detecting the incoming modulated carrier waves. A radio frequency by-pass condenser 8 and a choke coil 9 are preferably connected in the output circuit of the detector in the usual manner. The filament and anode energizing sources 10 and 11, respectively, are provided for the usual purpose and may be included in sources 4 and 5. An audio frequency transformer T₂ may be uti-

lized to couple the output circuit of the detector to any desired load circuit. The detector may feed one or more audio frequency amplifying stages, as is well known, or it may work into any desired impedance.

In accordance with the present invention I provide in the grid-cathode or input circuit of detector D, a resistor R and a condenser C in shunt therewith. These elements comprise a time circuit, as is well understood, and the inherent time lag action thereof may be given any desired value by assigning proper predetermined values to the resistance and condenser. One extremity of the parallel circuit including the elements just mentioned is connected by conductor 12 through filter resistor 13 to one terminal of the secondary winding of transformer T. A radio frequency by-pass and filter condenser 14 is connected between the point of connection of conductor 12 and the ground connection of the input circuit of tube V. Filter resistor 13 functions in conjunction with condenser C, resistor R and condenser 14 to filter out any alternating currents in the control circuit. The purpose of the arrangement just described is, as previously indicated, to derive a uni-directional control voltage whose amplitude is proportional to that of the incoming carrier wave and apply such control voltage to the radio frequency amplifier or amplifiers ahead of the detector.

It will be noted that no normal biasing voltage is provided for the control grid of detector D, which device operates in the manner of the usual grid-leak detector by virtue of the elements utilized herein for control purposes. The manner of operation of a grid-leak detector is well known and it is deemed unnecessary to describe such action herein except as it is affected by the present invention. Since no biasing potential is applied to the grid of the detector, this element will remain at substantially zero potential with respect to the cathode during inoperative periods when no carrier wave is being received. Practically no current flow takes place in the grid-cathode circuit of the detector at this time and only a very small voltage is established across resistor R and, therefore, substantially no control voltage is applied to the control grid of tube V.

Assuming now that a carrier wave is present and excites the system, tube V, being substantially unbiased, will initially operate in the usual manner over a portion of its characteristic curve to give the desired high amplification of the incoming carrier wave. During one-half cycle of the carrier wave, when the potential across the secondary of transformer T₁ has the polarity indicated on the drawing and the grid of tube D is positively charged, the grid will attract electrons emitted from the filament or cathode and grid rectification current will flow in the input circuit of detector tube through resistor R. The voltage set up across the resistor by this current flow will have the polarity indicated on the drawing so that a negative control or biasing potential will be applied to the control grid of tube V to effect the desired efficiency change thereof in accordance with the amplitude of the carrier. During the first few or initial cycles of the incoming carrier wave, condenser C will be gradually charged until the peak voltage of the applied wave is reached and this condenser will discharge slightly through resistor R during the alternate half cycles when the voltage applied to the control

grid goes negative and no grid rectification current flows through resistor R. The condenser and resistor are given such values as to maintain a desired value of the control voltage across resistance R when a carrier wave of predetermined small amplitude is being received. The resistance of ohms times the capacity in farads should be of the order of .0001 in seconds.

Should the amplitude of the incoming carrier increase, a correspondingly increased grid rectification current will flow in the input circuit of tube D, causing a proportionate increase in the control voltage set up across resistor R. This increased biasing voltage being applied to tube V will decrease its efficiency and cause a decrease in the amplitude of the carrier wave applied to tube D.

In Fig. 2, there is illustrated a modified system, it being understood that the portion not illustrated is similar to Fig. 1. In this system a specially constructed screen grid tube is utilized as a grid-leak detector. The use of a screen grid tube as a detector is highly desirable, as is well known, because of the high audio amplification which is had with this type of tube. The fact that such a tube overloads easily when used as a grid-leak detector has, however, precluded its use in this manner. In accordance with the embodiment of the invention illustrated in Fig. 2, I provide means which enables the practical use of a screen grid tube as a grid-leak detector, thereby obtaining the advantages inherent in this type of tube as well as in the particular manner of detection.

In order to adapt the screen grid tube to grid-leak detection, I provide an auxiliary grid 15 in the tube, which grid is interposed between the screen grid and the anode or plate and is connected, as at 16, to the control grid conductor. Aside from this modification, the tube takes the form of the usual screen grid tube, the construction of which is now well known. As is usual, the screen grid is connected to a suitable point of the anode supply source to provide the desired potential on the screen grid. Suitable provision must be made for insuring that a path which has a low impedance to audio frequency currents exists between the screen and cathode. A 0.25 micro-farad condenser may be used in this circuit. I have found that by modifying the tube in the manner illustrated and described, overloading is reduced and high gain is had. The auxiliary grid constitutes a second control grid, as is obvious from its manner of connection in the circuit. Most of the grid amplifying action however is had by the main control grid disposed adjacent the cathode, and the auxiliary grid merely assists the main control grid in its detection of the modulated carrier wave. By virtue of its position, however, the auxiliary grid influences the plate of anode in such a manner as to prevent the overloading action which is inherent in the ordinary screen grid tube when used as contemplated herein. Radio frequency choke 18 may be inserted in series with the grid lead as shown, in order that this grid may be influenced chiefly by audio frequency voltages built up across RC. The system of Fig. 2 operates in the same general manner as described above in connection with Fig. 1 insofar as the principles of automatic volume control are concerned.

In Fig. 3, there is illustrated a further modified system embodying the principles of the invention. In this system, the use of a screen tube

as a grid-leak detector is made possible by a different modification thereof from that of Fig. 2, and the tube is made to operate as a highly sensitive amplifier of the audio frequency currents in addition to its rectification action. In this embodiment, the main control grid is positioned between the screen grid and the plate or anode instead of in its usual position adjacent the cathode as in the ordinary screen grid tube. Furthermore, there is provided an auxiliary grid 17 which is positioned between the cathode and screen grid to take the place of the usual control grid and connected to the input circuit at one extremity of resistor R, as illustrated. This auxiliary grid may be considered as an auxiliary control grid which functions to apply the audio frequency voltage appearing across resistor R to the tube which in turn functions as a sensitive amplifier to amplify such voltage after the control grid has rectified or demodulated the incoming carrier wave. The main control grid serves, in conjunction with the cathode, to rectify the incoming carrier wave, these two electrodes of the tube constituting a simple two-electrode valve or rectifier. The grid rectification currents flowing through resistor R are utilized to derive the desired unidirectional control voltage, as hereinbefore described, and the audio frequency voltages appearing across resistor R as a result of the audio frequency component of the rectified currents flowing therethrough, are applied between the cathode and the auxiliary grid 17, which elements constitute the input of the device in its function as an audio frequency amplifier. The amplified audio frequency currents flowing in the anode or output circuit may be transferred by a transformer to the load circuit.

An important practical advantage of the circuit of Fig. 3 is that three-element detectors of all the well known types are often overloaded because the radio frequency voltage applied to the grid is amplified as much as by the audio frequency voltage, and with low percentages of modulation the radio frequency voltage may overload the detector plate circuit long before the audio frequency output voltage is of sufficient intensity. In this instance, the radio frequency is applied to a grid of low amplification for rectification, whereas the resultant audio frequency voltage is applied to a grid of high amplification. The two actions assist each other to provide efficient detection.

Aside from the operation just described, this modified form of the invention functions in the same manner as described above in connection with Fig. 1. The principles utilized in the system of Fig. 1 to derive and apply the uni-directional control voltage are utilized in the system of Fig. 3.

The circuit of Fig. 4 is similar to that of Fig. 3, except that filter condenser 19 and filter resistor 20 are provided so that the audio frequency energy applied to the control grid 17 will be substantially free of radio frequency energy. The advantage of this arrangement is that less overload will occur.

In the modified system of Fig. 5, the use of a screen grid tube as a grid-leak detector is made possible by providing an auxiliary grid 21 between the screen grid and the anode, such auxiliary grid being connected as at 22 to the filament or cathode at a point which may be midway between the extremities of this element. Aside from this modification, the tube takes the

form of the usual screen grid tube. The auxiliary grid, of course, has the same potential as the point of the cathode to which it is connected. The effect of this grid is to influence the plate or anode in such a manner as to minimize secondary electron emission from the plate which is possible in the ordinary screen grid tube when used as contemplated herein. The use of an auxiliary grid next to the anode, maintained at a potential near that of the cathode serves to increase the overload properties of the tube, as is well understood in the art relating to five-element tubes.

It is important to note that a useful action can be obtained from many multi-grid tubes, wherein one grid-cathode circuit is used in conjunction with a time circuit to provide rectified voltages including uni-directional and audio frequency voltages, said rectified voltages being applied to another of said grids to amplify said voltages. The terms "main control grid", and "auxiliary control grid" as used herein must be read in the light of this statement, and applied accordingly.

It is important to note that in each of the systems disclosed herein, condenser C functions as the usual grid condenser of the grid-leak detector and resistor R serves as the usual grid-leak to relieve the grid of accumulated electrons between wave trains. The detector circuit utilized has the inherent high gain of grid-leak detectors and in addition provides a substantial amount of control energy which may be utilized to control the carrier wave output volume from the radio frequency amplifier tube in the manner described. By means of the invention, the advantages of grid-leak detection are had and the detector is made to serve additionally as a source of control energy in somewhat the same manner as in the well-known automatic volume control system using a two-element rectifier. Where two or more radio frequency amplifiers are used, the application of the derived uni-directional control voltage to more than one of such amplifiers will obviously enhance the automatic volume control action.

It is to be noted that the cathodes of all the tubes may be returned to ground potential, and that there is no necessity for balancing a battery voltage against a potential drop in a resistor. The tubes may all be supplied from the same source of plate circuit energization. These are important features, due to variation of the characteristics of tubes in service. These advantages have not heretofore been obtainable in systems having multi-element detectors using automatic volume control.

Although specific circuit arrangements are disclosed for the purpose of illustration, any changes in the details thereof, the essential features of the invention remaining undisturbed, are deemed to be within the scope of the invention. Only such limitations as are included within the appended claims are to limit the invention.

I claim:

1. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, a main control grid, and an auxiliary control grid, means for applying the amplified carrier frequency signal voltage between one of said grids and said cathode, means for deriving uni-directional and audio frequency voltages from the input circuit of said detector tube, the value of said uni-directional voltage depending on the carrier voltage,

means for applying said uni-directional voltage to at least one of said carrier frequency amplifying tubes, whereby the efficiency of said amplifying tubes is modified in accordance with the carrier wave amplitude, and means for applying said audio frequency voltage between another one of said grids and said cathode.

2. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, a screen grid, a main control grid interposed between said screen grid and said anode, and an auxiliary control grid interposed between said cathode and said screen grid, means for applying the amplified carrier frequency signal voltage between said main control grid and said cathode, means for deriving uni-directional and audio frequency voltages from the input circuit of said detector tube, the value of said uni-directional voltage depending on the carrier voltage, means for applying said uni-directional voltage to at least one of said carrier frequency amplifying tubes, whereby the efficiency of said amplifying tube is modified in accordance with the carrier wave amplitude, and means for applying said audio frequency voltage between said auxiliary control grid and said cathode.

3. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, and at least two auxiliary electrodes for controlling the anode current; one of said auxiliary electrodes being arranged to control the anode current to a greater extent than another of said auxiliary electrodes, means for applying a modulated carrier wave to said other auxiliary electrode for demodulation, and means for applying demodulated signal potentials to the first-mentioned auxiliary electrode.

4. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, and at least two auxiliary electrodes for controlling the anode current, one of said auxiliary electrodes being arranged to control the anode current to a greater extent than another of said auxiliary electrodes, means for applying a modulated carrier wave to said other auxiliary electrode for demodulation, means for deriving demodulated signal potentials and a uni-directional voltage as a result of demodulation, the value of said voltage depending upon the carrier voltage, means for applying said signal potentials to the first-mentioned auxiliary electrode, and means for applying said uni-directional voltage to at least one of the carrier frequency amplifying tubes, whereby the efficiency of said tubes is modified in accordance with the carrier wave amplitude.

5. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, a main control grid interposed between said cathode and said anode, and an auxiliary control grid interposed between said cathode and said main control grid, means for applying the amplified carrier frequency signal voltage between said main control grid and said cathode, means for deriving unidirectional and audio frequency voltages from the input circuit of said detector tube, the value of said unidirectional voltage depending on the carrier voltage, means for applying said unidirectional voltage to at least one of said carrier frequency amplifying tubes, whereby the efficiency of said amplifying tube is modified in accordance with the carrier wave amplitude, and

means for applying said audio frequency voltage between said auxiliary control grid and said cathode.

6. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, a main control grid interposed between said cathode and said anode, and an auxiliary control grid interposed between said cathode and said main control grid, whereby said auxiliary control grid is arranged to control the anode current to a greater extent than said main control grid, means for applying a modulated carrier wave to said main control grid for demodulation, and means for applying demodulated signal potentials to said auxiliary control grid.

7. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, a screen grid, a main control grid interposed between said screen grid and said anode, and an auxiliary control grid interposed between said cathode and said screen grid, whereby said auxiliary control grid is arranged to control the anode current to a greater extent than said main control grid, means for applying a modulated carrier wave to said main control grid for demodulation, and means for applying demodulated signal potentials to said auxiliary control grid.

8. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, a main control grid, and an auxiliary control grid, means for applying the amplified carrier frequency signal voltage between one of said grids and said cathode, means for deriving unidirectional and audio frequency voltages from the input circuit of said detector tube, the value of said unidirectional voltage depending on the carrier voltage, means for applying said unidirectional voltage to at least one of said carrier frequency amplifying tubes, whereby the efficiency of said amplifying tubes is modified in accordance with the carrier wave amplitude, means for filtering said audio frequency voltage, and means for applying the filtered voltage between another one of said grids and said cathode.

9. In a carrier wave receiving system, one or more carrier frequency amplifying tubes, a detector tube having a cathode, an anode, and at least two auxiliary electrodes for controlling the anode current, one of said auxiliary electrodes being arranged to control the anode current to a greater extent than another of said auxiliary electrodes, means for applying a modulated carrier wave to said other auxiliary electrode for demodulation, means for filtering the demodulated signal potentials, and means for applying the filtered signal potentials to the first-mentioned auxiliary electrode.

10. In a radio receiving system, an amplifying tube operating at high frequency, a detector tube having a cathode, an anode, and a plurality of grids disposed between said cathode and said anode to control the flow of space current therebetween, a high frequency input circuit for said detector including said cathode and one of said grids, means for supplying high frequency signal energy from said amplifier to said input circuit, an audio frequency output circuit for said detector including said cathode and said anode, means for deriving from said input circuit a unidirectional control voltage whose value depends on the amplitude of the incoming signal, means for applying said voltage to said amplifier to control the

gain thereof, and means for applying demodulated signal potentials to another of said grids.

11. In a radio receiver, the combination with a carrier wave amplifier, of a detector tube having a cathode, a main control grid, a positively polarized output anode, and an auxiliary control grid, an input circuit for said tube upon which the carrier wave output of said amplifier is impressed, said input circuit being connected between the cathode and said main control grid and including, in series, a carrier-wave coupling element and a resistor shunted by a condenser, means grounding said tube cathode, a connection between said auxiliary control grid and the junction of said resistor and said coupling element for impressing the audio frequency potential component of demodulated carrier waves upon said auxiliary control grid, and an audio frequency output circuit connected between the said cathode and said output anode.

12. In combination with a radio frequency sig-

nal amplifier of the type including at least one tube provided with a gain control electrode, a detector stage following the amplifier and including a tube provided with a cathode, an anode, and at least two space current control electrodes, an audio frequency output circuit connected between said cathode and said anode, a signal input network connected between one of said control electrodes and said cathode, the other of said control electrodes being connected to said input network, both said control electrodes being connected to the high alternating current potential side of said network, a resistor in circuit with at least said one control electrode and said cathode for developing a direct current gain control bias for said amplifier tube, and a direct current connection between a point of negative potential on said resistor and the said gain control electrode.

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