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AUTOMATIC VOLUME CONTROL CIRCUIT

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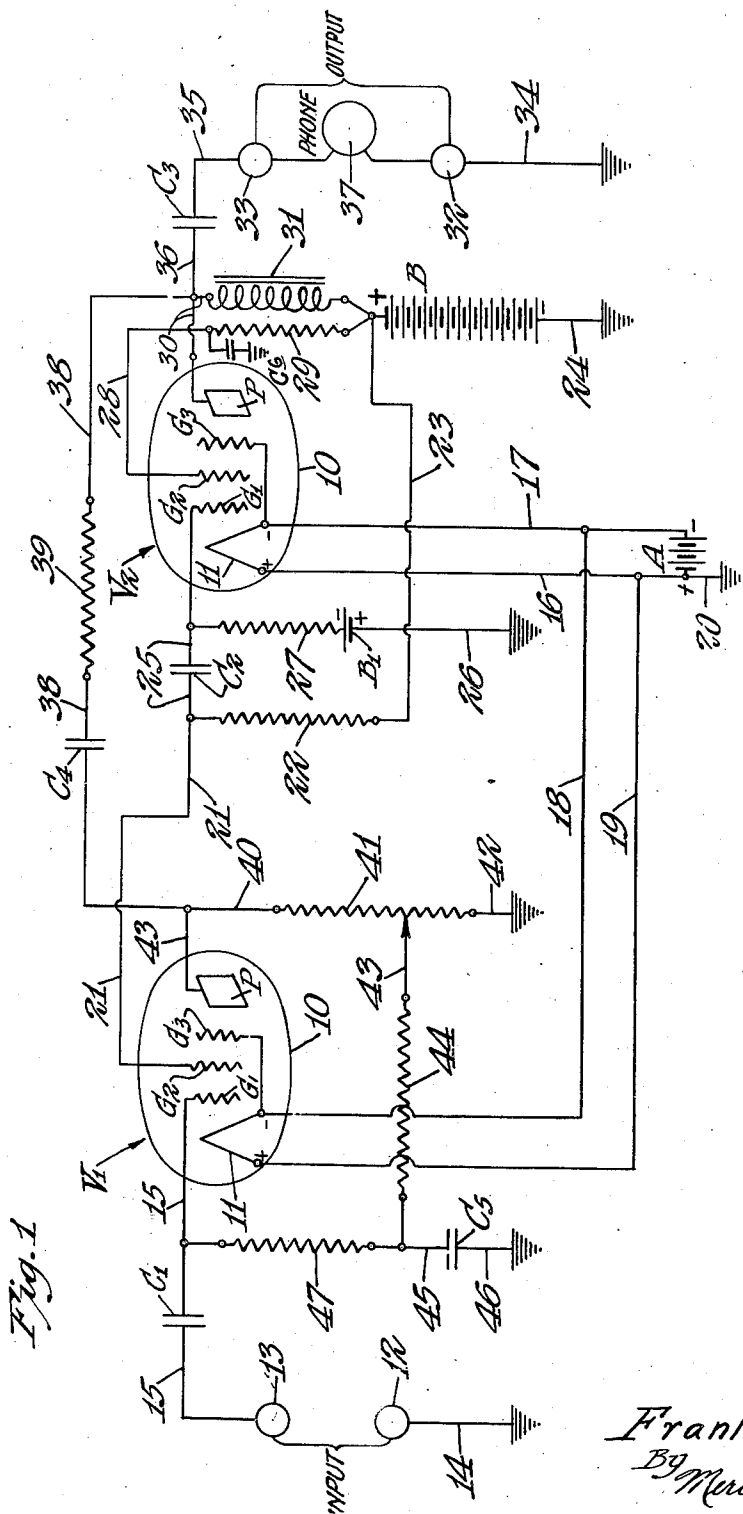


Fig. 1

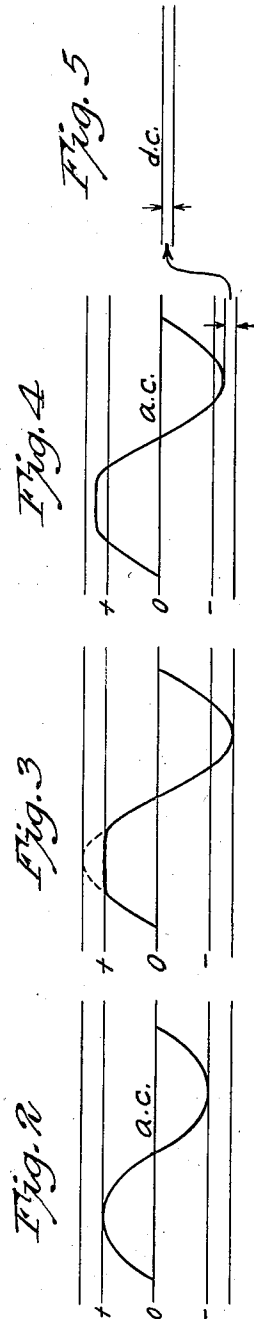


Fig. 2

Fig. 3

Fig. 4

Fig. 5

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AUTOMATIC VOLUME CONTROL CIRCUIT

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My present invention relates to an improved system of automatic volume control for electronic amplifiers and encompasses within it both method of and apparatus for automatically suppressing signals of undesirably high amplitude. While the invention was primarily designed for use in connection with, and has particular advantages when used in connection with, audio frequency or speech amplifiers of the light and compact variety used in hearing aids; it should, nevertheless, be understood that the invention may be advantageously employed in electronic amplifiers operating at various other frequencies; such, for example, as radio frequencies or intermediate frequencies.

Broadly stated, the present invention relates to improvements in that type of volume control wherein signal voltage above a desired value developed in a circuit of the amplifier is rectified and thereafter utilized to bias an amplifier tube to thereby decrease the amplification factor thereof. The elements of an electronic rectifier, namely: anode and cathode, are essential to this type of volume control and the signal level or amplitude at which rectification and consequent volume suppression will begin is customarily controlled by bleeding current from the amplifier's high voltage D. C. supply through a resistor or voltage divider and using part or all of the voltage drop across such resistor to bias the rectifier in a manner to prevent the flow of electrons from the rectifier anode to cathode, except when the applied signal voltage rises to a sufficient value to overcome the bias effect on the rectifier and permit rectification, such biasing of the rectifier elements being often referred to as the establishment of threshold or threshold voltage. In utilizing this type or character of volume control according to the hitherto accepted practice, either an additional tube was used in the amplifier unit to provide the desired rectification or a special dual-purpose tube having extra elements useable for the purpose of rectification has been employed for biasing purposes. In either event, however, the volume control system imposed an additional load on the amplifier's high voltage D. C. source or required the use of an additional D. C. high voltage supply source, and in cases where an extra tube was employed for A. V. C. action, an additional load was also placed upon the amplifier's low voltage filament power supply. Of course, in the case of portable amplifying units, and particularly in the case of very light and ultra-compact hearing aid amplifier units which are customarily operated from self-contained small A

and B dry cell batteries, the use of extra tubes or other parts for A. V. C. action is highly undesirable as is also the imposing of any extra load upon the A or B batteries to accomplish A. V. C. action; the latter because any increased load on the batteries essentially requires larger batteries for equal life or results in shorter life for given size batteries.

Primary objects of my present invention are, therefore, to provide improved methods and apparatus whereby volume suppression may be achieved in an electronic amplifier without placing any additional burden upon the amplifier's source or sources of potential, without the use of extra source of potential, and without the use of extra tubes or special complex and often undesirable special purpose tubes. While these features are highly desirable in electronic amplifiers generally, they are particularly desirable in connection with audio or voice amplifiers of the compact and lightweight variety used in connection with personal hearing aids, in which, because all the elements of the hearing aid, including the amplifier and its dry cell potential sources, are worn on the person of the user, long battery life and the reduction of bulk and weight to the greatest possible extent are primary objectives.

Generally stated, the above and other important objects and advantages of my invention may be achieved in connection with a multi-stage electronic amplifier in the following manner, to wit: For the purpose of this example, it will be assumed that the amplifier unit utilized has at least two stages employing an amplifying device in the nature of a vacuum tube in each of said stages, and is equipped in a stage preceding the final stage thereof with an electronic amplifier in the nature of a vacuum tube having, in addition to the customary plate, cathode, and control grid, another grid that is electrically closer to the plate than is the control grid. As a preferred first step toward incorporating my volume control system in such an amplifier, the said other grid of the preceding stage tube is connected as an output anode or plate in an output circuit for said tube, and which output circuit may be of conventional character and may be assumed to be coupled to an input circuit of a succeeding stage in conventional manner. This output circuit should include a source of D. C. potential maintaining the output anode-acting grid charged positively with respect to the cathode of that tube, so that the amplifier will function as such independently of the plate of said preceding stage tube. Now, for the purpose of volume control action, signal volt-

age from a succeeding stage may be fed back to the plate of said preceding stage tube, thereby causing the plate and cathode of said tube to function as the elements of a rectifier whenever peak positive values of signal voltage exceed the value of the positive D. C. potential impressed upon the grid of said preceding stage tube, and which is now serving as an output anode; it being understood that, because of the location of the output anode-acting grid of the preceding stage tube between the cathode and plate thereof, the positive D. C. potential impressed upon the said output anode-acting grid will prevent the flow of electrons from the cathode to the plate of said tube except when the plate is given a positive charge exceeding that of the output anode-acting grid. From this, it will be clear that the positive voltage applied to the output anode-acting grid of the preceding stage tube serves as a threshold voltage which must be exceeded by positive peak values of signal voltage fed back to the plate from the succeeding stage to start rectification, and that such relatively high signal voltage as is required to exceed the established threshold voltage will result only from positive feed-back signal voltage of high amplitude. With this arrangement, only A. C. signal voltage is present at the plate of the preceding stage tube when positive peak values of feed-back signal voltage are below the positive threshold potential impressed upon the output anode-acting grid of that tube. However, when the feed back signal voltage exceeds said positive threshold voltage, rectification takes place and there is available at the plate, in addition to an A. C. voltage, a pulsating negative voltage which may be utilized for automatic volume control action. In accordance with the preferred embodiment of the invention, this D. C. negative component, whenever it is present, is filtered to minimize pulsations and is then impressed upon the control grid of the preceding stage 2 as a bias to reduce the amplification factor or current-passing capacity of that tube to thereby produce the desired volume suppression. However, it should be understood that it is within the spirit of the invention to impress this negative D. C. component as a bias on the control grid of any one or more of the amplifier's tubes.

The above noted and other highly important objects and advantages of the invention and the operation of a preferred embodiment of the invention will be made further apparent from the following specification, claims, and appended drawing.

In the accompanying drawing, like characters indicate like parts throughout the several views.

Referring to the drawing:

Fig. 1 is a diagrammatic view illustrating a preferred embodiment of the invention incorporated in an audio or voice frequency amplifier;

Figs. 2, 3, and 4 are wave form diagrams; and

Fig. 5 is a diagrammatic illustration of the direct current component of the wave form of Fig. 3.

The amplifier of Fig. 1 is a two stage audio or voice frequency amplifier employing a multiple grid electronic amplifier in the nature of a vacuum tube in each of its successive stages, the tube of the first stage being indicated by V^1 and the tube of the second stage being indicated by V^2 . The tube V^1 is a conventional high gain pentode radio tube, preferably of the variable μ type, and the tube V^2 is a conventional high power output type of pentode radio tube. The tubes V^1 and V^2 each comprise an envelope 10 and elec-

trodes 11, G^1 , G^2 , G^3 , and (P). The electrodes 11 are electrically energized filaments which serve as directly heated cathodes; the electrodes (P) are the usual plates which are primarily intended to function as output anodes; and the electrodes G^1 , G^2 , and G^3 are respectively the control grids, screen grids, and suppressor grids. These grids G^1 , G^2 , and G^3 are interposed between the electrodes 11 and (P) and are respectively spaced progressively further from the electrode 11.

The amplifier is provided with a pair of input terminals or binding posts 12 and 13, through which the amplifier may be connected to a suitable source of signal voltage such, for example, as a microphone (not shown). The input circuit to tube V^1 is conventional and comprises the lead 14 connecting the terminal 12 to ground, and a lead 15 connecting the terminal 13 to the control grid G^1 of tube V^1 and having interposed therein the conventional coupling condenser C^1 . The normal biasing and the volume control biasing of the tube V^1 will later be described.

The cathode-acting filaments 11 of the tubes V^1 and V^2 are energized from a suitable source of D. C. potential such as an A battery (A) through parallel circuits comprising leads 16, 17, 18, and 19. In accordance with the present example, the positive side of the battery (A) is connected to ground through a lead 20. As previously indicated, a grid of V^1 that is closer to the plate (P) than is the control grid G^1 is connected in the manner of a plate to act as an output anode. In a tube of the character described, the screen grid G^2 thereof is selected for this purpose, and, as shown, is connected in a suitable output circuit comprising a lead 21, a load resistor 22, and a lead 23 connecting to the positive side of a suitable source of D. C. potential, such as a B battery (B) having its negative side connected to ground through a lead 24. The input circuit to the control grid G^1 of V^2 is conventional and comprises a lead 25 having interposed therein a coupling condenser C^2 . Control grid G^1 of V^2 is biased negatively with respect to the cathode-acting filament thereof through a ground lead 26, a dry cell or cells B^1 , and a resistor 27. The screen grid G^2 of tube V^2 is connected in conventional manner to the positive side of the B voltage supply through a lead 28 and series resistance 29. A bypass condenser C^3 is preferably connected from G^2 to ground, as shown.

The output anode or plate (P) of V^2 is connected in a conventional output circuit comprising a lead 30 and a plate-loading choke 31, one side of which is tied to the positive side of the B voltage supply (B). The output side of this amplifier is provided with a pair of output binding posts or terminals 32 and 33, the former being connected to ground by a lead 34, and the latter being tied to the plate (P) through a lead 35, a condenser C^3 , a lead 36, and part of lead 30. These output terminals 32 and 33 adapt the amplifier to be connected to the input of any device or apparatus to be energized by signal voltage developed in the amplifier, such, for example, as an earphone 37 or the like.

Now, it will be seen that, if the control grid G^1 of tube V^1 is properly biased, the tube V^1 will function as a triode amplifier and the complete amplifier unit will function, as such, whenever a source of signal voltage is connected across the input terminals 12 and 13. The normal amplifier function is, of course, accomplished independently of the plate (P) of tube V^1 .

Now, for the purpose of volume control, a feed-

back circuit is established from the output of V^2 and, as shown, this feed-back circuit comprises a lead 38, series resistor 39, a direct current blocking condenser C^4 , a lead 40, and a resistor 41 that is connected to the ground side of the circuit by a ground lead 42. Now, the plate (P) and cathode-acting filament 11 of tube V^1 are connected as the elements of a diode rectifier in shunt across the resistor 41 by a circuit comprising a lead 43, and leads 19 and 20. The resistor 41 is preferably of the type having a sliding or adjustable tap 43, such as a conventional potentiometer, and this tap 43 is connected in a filter and time delaying circuit comprising a resistor 44, a lead 45, a by-pass condenser C^5 , and a ground lead 46.

In order to obtain a normal zero bias on the grid G^1 of tube V^1 , the said grid is connected to ground (B negative) through lead 15, a resistor 47, resistor 44, part of resistor 41, and ground lead 42.

Preparatory to describing the operation in detail, attention is directed to the fact that the relatively high positive D. C. voltage impressed upon the grid G^2 of tube V^1 serves as a threshold voltage which must be exceeded by positive voltage impressed upon the plate (P) of said tube before an electronic path can be established between the cathode-acting filament 11 and plate (P) of said tube. In other words, the high positive D. C. threshold voltage normally impressed upon the output anode-acting grid G^2 of V^1 by battery (B) attracts the flow of electrons from the cathode-acting filament 11 of said tube away from the plate (P) of said tube and, therefore, prevents the flow of positive current from plate to filament of V^1 , except when the positive voltage impressed upon the plate of V^1 exceeds the positive potential impressed upon grid G^2 of said tube. Now, therefore, since the D. C. blocking condenser C^4 is incorporated between leads 38 and 40, it will be apparent that the only potential ever impressed upon the plate (P) of V^1 is in the form of A. C. signal voltage and that such signal voltage will produce a current flow through the rectifier-acting elements (P) and 11 of V^1 when, but only when, the peak positive values of signal voltage impressed upon (P) of V^1 exceed the positive D. C. potential impressed upon G^2 of V^1 .

Operation

Now, bearing in mind the facts just above recited and assuming that a suitable source of signal voltage, such as a microphone, pre-amplifier, phonograph pick-up, radio receiving set, or the like, is connected across the input terminals 12 and 13, it will be clear that the electrodes 11, G^1 , and G^2 of tube V^1 will function as a triode amplifier and that the amplifier, as an entirety, will function normally, except for automatic volume control action, independently of the plate (P) of V^1 . During the entire operation of this amplifier, A. C. signal voltage developed in the output circuit of the succeeding stage tube V^2 is fed back to and impressed upon the plate (P) of the preceding stage tube V^1 , but so long as the peak positive values of such fed back signal voltage are below the value of the positive D. C. potential impressed on the grid G^2 of tube V^1 , no rectifier action will take place between (P) and 11 of V^1 , and only pure A. C. voltage will appear across the resistor 41. The form of this peak A. C. signal voltage appearing across resistor 41 under all conditions when the peak positive values of signal voltage are below the

value of the positive potential impressed upon G^2 of V^1 is indicated by the wave form line in Fig. 2, and the magnitude of the positive D. C. voltage (threshold voltage) impressed upon the plate G^2 of V^1 is indicated by the space between horizontal lines marked 0 and plus mark respectively in Fig. 2. Such A. C. signal voltage is, of course, passed to ground in its entirety, going in part through lead 42 and in part through resistor 44, condenser C^5 and lead 46. However, when the peak positive values of A. C. signal voltage fed back to the plate (P) of V^1 exceed the positive D. C. threshold voltage applied to grid G^2 of V^1 , such positive peak values of signal voltage as do exceed the said positive D. C. threshold voltage on grid G^2 of V^1 will be by-passed from plate (P) to filament 11 of V^1 and from thence to ground (B negative) through leads 19 and 20. The wave form of the voltage developed across the resistor 41 under these conditions is indicated by the unbroken wave form line of Fig. 3, wherein the horizontal lines marked 0 and plus mark respectively correspond exactly to those of Fig. 2. Referring further to Fig. 3, it will be seen that the positive peak values of signal voltage that exceed the threshold voltage and are, therefore, by-passed through the circuit comprising the rectifier elements (P) and 11 of V^1 , are indicated by the dotted wave form line. The wave form of Fig. 3 is representative of an A. C. voltage with a negative D. C. component, and this is quite clearly indicated by Figs. 4 and 5, the former of which represents the A. C. component of Fig. 3, and the latter of which indicates the negative D. C. component of Fig. 3. Under the last noted conditions, when positive peak values of signal voltage exceed the positive threshold voltage impressed upon G^2 of V^1 , the A. C. component developed across resistor 41, and which is indicated by the unbroken wave form line of Fig. 4, will be passed in its entirety to ground, going in part through lead 42 and in part through resistor 44, condenser C^5 , and lead 46; and a selected percentage of negative D. C. potential appearing across resistor 41 (the percentage depending upon the position of tap 43) will be by-passed through resistor 44 and impressed upon G^1 of V^1 through the grid resistor 47 and lead 15. While this negative D. C. voltage available for volume control biasing is initially of the pulsating variety, it should be understood that the filter network comprising resistor 44 and condenser C^5 flattens out such pulsations to the extent that a steady negative D. C. potential is applied as a volume control bias to the grid G^1 of V^1 .

With this system of volume control, the degree of volume suppression obtained can readily be varied by merely shifting the tap 43 of resistor 41 so as to make more or less of the negative D. C. component available for volume control purposes; and, of course greater volume control action may be readily obtained by adding one or more stages between V^1 and V^2 or by increasing the amplification factor of V^2 .

In defining and describing the present invention, the term "grid" has been used in a broad and liberal sense to designate, without regard to its physical character, any electrode of an electronic amplifier which may be capable of functioning, when positioned in the electronic path between two other electrodes, to control the flow of electrons between said other electrodes responsive to changes in applied potential; the term "plate" has been used in a broad and liberal sense to designate, without regard to its physical char-

acter, any electrode of an electronic amplifier to which electrons flow from a more negatively charged cathode or emitter under control of at least two intervening "grids"; and the term "cathode" is used in a broad and liberal sense to designate, without regard to its physical character, an electron emitter or source of electronic discharge of an electronic amplifier, without regard to whether or not it be heated or whether it be heated directly or indirectly.

While the tube V^1 has been described as being of the type having a suppressor grid tied to its filament or cathode, it should be understood that the invention is not dependent upon the presence of such a suppressor grid for its successful operation. However, the suppressor grid, when employed as in V^1 , has been found to materially improve the over-all results of the system described by acting as a capacity shield between positively charged grid G^2 and plate (P), thereby preventing or largely eliminating capacitive coupling between G^2 and (P). Hence, it will be seen that, whereas, the suppressor grid G^3 of tube V^2 functions in the normal accepted manner, the suppressor grid G^3 of tube V^1 contributes an entirely different but, nevertheless, important, function which, as indicated, is the reduction to a minimum of the capacity between grid G^2 and plate (P).

What I claim is:

1. In a multiple stage electronic amplifier system in which one stage preceding the final stage employs an electronic amplifier having, in addition to the usual cathode, plate, and control grid, another grid which when electrically charged will modify the flow of electrons from said cathode to said plate, the said other grid of said preceding stage amplifier being connected as an anode in an output circuit that is connected to the input circuit of the succeeding stage in the manner usually assigned to a plate and having impressed thereon a positive D. C. potential of pre-determined value, whereby the said electronic amplifier of the preceding stage and the amplifier system as an entirety will function normally, except for automatic volume control action, independently of the plate of said preceding stage amplifier, means feeding back signal voltage from the output of a succeeding stage to the plate of said electronic amplifier of the preceding stage, whereby rectification will take place between the plate and cathode of said preceding stage amplifier when, but only when, peak values of positive signal voltage exceed the positive D. C. potential impressed upon the said other grid of the preceding stage amplifier, and means for applying a pre-determined percentage of the negative D. C. voltage available at the said plate as a result of rectification to the control grid of an electronic amplifier of the said system to serve as a volume suppressing bias.

2. The structure defined in claim 1 in which the said signal voltage feed back means to the plate of the preceding stage amplifier includes a series condenser.

3. The structure defined in claim 1 in which the said signal voltage feed-back means to the plate of the preceding stage amplifier includes a serially connected condenser and resistance.

4. The structure defined in claim 1 in which the said means for applying a negative D. C. potential as a volume suppressing bias includes a suitable filter network for filtering out the pulsations before application to the control grid.

5. The structure defined in claim 1 in which

the said means for applying a negative D. C. potential as a volume suppressing bias includes a resistance capacity network shunting out A. C. signal voltage and flattening out the pulsations in the negative D. C. biasing voltage.

6. In a multiple stage electronic amplifier system in which one stage preceding the final stage employs an electronic amplifier having, in addition to the usual cathode, plate, and control grid, another grid which when electrically charged will modify the flow of electrons from said cathode to said plate, the said other grid of said preceding stage amplifier being connected as an anode in an output circuit that is connected to the input circuit of the succeeding stage in the manner usually assigned to a plate and having impressed thereon a positive D. C. potential of pre-determined value, whereby the said electronic amplifier of the preceding stage and the amplifier system as an entirety will function normally, except for automatic volume control action, independently of the plate of said preceding stage amplifier, a signal voltage feed-back circuit from the output of a succeeding stage and which involves a direct current blocking condenser and a resistance, an electrical connection between the plate of said preceding stage electronic amplifier and a point in said feed-back circuit intermediate said condenser and said resistance and which establishes a rectifier shunt circuit around said resistance comprising the plate and cathode of said preceding stage electronic amplifier, the said positive D. C. potential impressed upon the said other grid of the preceding stage electronic amplifier serving as a threshold voltage tending to repel electronic flow from cathode to plate of said preceding stage amplifier except when positive peak values of signal voltage impressed upon the plate of said preceding stage amplifier exceed the said threshold voltage impressed upon the said other grid of said amplifier, whereby the plate and cathode of said preceding stage amplifier will function as the elements of a rectifier and an A. C. voltage with a D. C. component will be developed across said resistance whenever positive peak values of signal voltage fed back to the plate of said preceding stage amplifier exceed the threshold voltage impressed upon the said other grid of the last said amplifier, a shunt circuit around a pre-determined percentage of said resistance and which includes an A. C. voltage bypassing condenser, and an electrical connection from the control grid of the said preceding stage electronic amplifier to a point in the last said shunt circuit before said condenser, whereby the negative component developed across said resistance under conditions before described will be impressed upon the control grid of the preceding stage electronic amplifier as a volume suppressing bias.

7. The structure defined in claim 6 in which the said signal voltage feed-back circuit further includes a resistance in series with the said condenser and located between the succeeding stage and the plate of the preceding stage.

8. The structure defined in claim 6 in which the last said shunt circuit includes a resistance located between the before mentioned resistance of the feed-back circuit and the condenser in the last said shunt circuit.

9. The structure defined in claim 6 in which the electrical connection between the last said

shunt circuit and control grid of the preceding stage amplifier includes a grid resistance.

10. The structure defined in claim 1 in which the said electronic amplifiers of the preceding and succeeding stages are in the nature of electronic vacuum tubes, and in which the tube of the preceding stage further includes a suppressor grid that is closer to the plate than either of the before mentioned grids.

11. In a multiple stage vacuum tube amplifier employing a multiple grid tube in a stage preceding the final stage thereof, said preceding stage involving an output circuit wherein a grid of said multiple grid tube other than the control grid is connected as signal output anode, said output circuit including a source of D. C. potential impressing a positive voltage of predetermined value upon the last said grid, whereby said multiple grid tube will function as an electronic coupling device and the amplifier will function as such independently of the plate of said tube, and an automatic volume control for said amplifier comprising a signal voltage feed-back circuit energized from the signal voltage output circuit of a stage succeeding the said multiple grid tube and which circuit includes the plate and cathode of said multiple grid tube of the preceding stage, whereby the plate and cathode of said preceding stage multiple grid tube will function as the elements of a rectifier when, but only when, peak values of positive signal voltage fed back from the succeeding stage exceed the positive D. C. potential applied to the anode-acting grid of the last said tube, and a strictly D. C. coupling between the rectifier-acting plate of said multiple grid tube and the control grid on tube of the amplifier, whereby negative D. C. potential appearing at the rectifier-acting plate of the multiple grid tube of the preceding stage will be impressed, as a volume control bias, upon the control grid of said other tube.

12. A method of providing automatic volume control in a multiple stage vacuum tube amplifier employing a multiple grid tube in a stage preceding the final stage which comprises connecting a grid of said multiple grid tube other than the control grid thereof to operate as an anode in a voltage output circuit which impresses upon the said anode-acting grid a positive D. C. potential of pre-determined value, whereby said multiple grid tube of the preceding stage will operate as an electronic coupling device independently of its plate, feeding back signal voltage from the succeeding stage to the plate of said multiple grid tube of the preceding stage so that the said plate and the cathode of said multiple grid tube will function as the elements of a rectifier when, but only when, the peak positive values of feed-back signal voltage from the succeeding stage exceed the value of positive D. C. potential applied to the anode-acting grid of the said multiple grid tube of the preceding stage, and impressing upon the control grid of a tube of the amplifier a pre-determined percentage of the negative D. C. potential appearing at the plate of said multiple grid tube while isolating said control grid from the A. C. component at said plate.

13. A method of accomplishing automatic volume control in a multiple stage vacuum tube amplifier employing a screen grid tube in a stage preceding the final stage which comprises connecting the screen grid of the screen grid tube of said preceding stage to function as an anode in an output circuit for said tube and coupling such output circuit to the input circuit of a suc-

ceeding stage, whereby the said screen grid tube of said preceding stage will function as an amplifier independently of its plate, feeding back signal voltage from the output circuit of a succeeding tube to the plate of the said screen grid tube of the preceding stage so that the said plate and the cathode of said screen grid tube will function as a diode rectifier when, but only when, the peak positive values of feed-back signal voltage from the succeeding stage exceed the value of the D. C. potential applied to the screen grid serving as an output anode in said screen grid tube, and impressing upon the control grid of a tube of the multiple stage amplifier a pre-determined percentage of the negative D. C. potential appearing at the diode-acting plate of said screen grid tube while isolating said control grid from the A. C. component at the said plate.

14. The structure defined in claim 1 in which the electronic amplifier of the preceding stage includes a grid that is closer to the plate than either of the aforesaid grids and is tied to the cathode of said amplifier.

15. In a multiple stage electronic amplifier system in which one stage preceding the final stage employs an electronic amplifier having, in addition to the usual cathode, plate, and control grid, another grid that is electrically closer to the plate than is said control grid, the said other grid of said preceding stage amplifier being connecting as an anode in an output circuit that is connected to the input circuit of the succeeding stage in the manner usually assigned to a plate and having impressed thereon a positive D. C. potential of pre-determined value, whereby the said electronic amplifier of the preceding stage and the amplifier system as an entirety will function normally, except for automatic volume control action, independently of the plate of said preceding stage amplifier, means feeding back signal voltage from the output of a succeeding stage to the plate of said electronic amplifier of the preceding stage, whereby rectification will take place between the plate and cathode of said preceding stage amplifier when, but only when, peak values of positive signal voltage exceed the positive D. C. potential impressed upon the said other grid of the preceding stage amplifier, and means for applying a pre-determined percentage of the negative D. C. voltage available at the said plate as a result of rectification to the control grid of an electronic amplifier of the said system to serve as a volume suppressing bias.

16. In a multiple stage electronic amplifier system in which one stage preceding the final stage employs an electronic amplifier having, in addition to the usual cathode, plate, and control grid, another grid that is closer to the plate than is said control grid, the said other grid of said preceding stage amplifier being connected as an anode in an output circuit that is connected to the input circuit of the succeeding stage in the manner usually assigned to a plate and having impressed thereon a positive D. C. potential of pre-determined value, whereby the said electronic amplifier of the preceding stage and the amplifier system as an entirety will function normally, except for automatic volume control action, independently of the plate of said preceding stage amplifier, a signal voltage feed-back circuit from the output of said succeeding stage and which involves a direct current blocking condenser followed by a resistance, an electrical connection between the plate of said preceding stage electronic amplifier and a point in said feed-back circuit

intermediate said condenser and said resistance and which establishes a rectifier shunt circuit around said resistance comprising the plate and cathode of said preceding stage electronic amplifier, the said positive D. C. potential impressed upon the said other grid of the preceding stage electronic amplifier serving as a threshold voltage tending to repel electron flow from cathode to plate of said preceding stage amplifier except when positive peak values of signal voltage impressed upon the plate of said preceding stage amplifier exceed the said threshold voltage impressed upon the said other grid of said amplifier, whereby the plate and cathode of said preceding stage amplifier will function as the elements of a rectifier and an A. C. voltage with a D. C. component will be developed across said resistance whenever positive peak values of signal voltage fed back to the plate of said preceding stage amplifier exceed the threshold voltage impressed upon the said other grid of the last said amplifier, a shunt circuit around a pre-determined percentage of said resistance and which includes an A. C. voltage by-passing condenser, and an electrical connection from the control grid of the said preceding stage electronic amplifier to a point in the last said shunt circuit before said condenser, whereby the negative component developed across said resistance under conditions before described will be impressed upon the control grid of the preceding stage electronic amplifier as a volume suppressing bias.

17. In a multiple stage vacuum tube amplifier employing a multiple grid tube in a stage preceding the final stage thereof, said preceding stage involving an output circuit wherein a grid of said multiple grid tube thereof that is electrically closer to the plate of said tube than is its control grid is connected as signal output anode, said output circuit including a source of D. C. potential impressing a positive voltage of pre-determined value upon the last said grid, whereby said multiple grid tube will function as an electronic coupling device and the amplifier will function as such independently of the plate of said tube, and an automatic volume control for said amplifier comprising a signal voltage feed-back circuit energized from the signal voltage output circuit of a stage succeeding the said multiple grid tube and which circuit includes the plate and cathode of said multiple grid tube of the preceding stage, whereby the plate and cathode of said preceding stage multiple grid tube will function as the elements of a rectifier when, but only when, peak values of positive signal voltage fed back from the succeeding stage exceed the positive D. C. potential applied to the anode-acting grid of the last said tube, and a strictly D. C. coupling between the rectifier-acting plate of said multiple grid tube and the control grid of said tube, whereby a negative D. C. potential appearing at the rectifier-acting plate of the multiple grid tube of the preceding stage will be impressed, as a volume control bias, upon the control grid of the last said tube.

18. A method of providing automatic volume control in a multiple stage vacuum tube amplifier employing a multiple grid tube in a stage preceding the final stage which comprises connecting a grid of said multiple grid tube that is electrically closer to the plate than is the control grid to operate as an anode in a voltage output circuit which impresses upon the said anode-acting grid a positive D. C. potential of pre-determined value, whereby said multiple grid tube of the preceding

stage will operate as an electronic coupling device independently of its plate, feeding back signal voltage from the succeeding stage to the plate of said multiple grid tube of the preceding stage so that the said plate and the cathode of said multiple grid tube will function as the elements of a rectifier when, but only when, the peak positive values of feed-back signal voltage from the succeeding stage exceed the value of positive D. C. potential applied to the anode-acting grid of the said multiple grid tube of the preceding stage, and impressing upon the control grid of said multiple grid tube of the preceding stage a pre-determined percentage of the negative D. C. potential appearing at the plate of said multiple grid tube while isolating said control grid from the A. C. component at said plate.

19. A method of providing automatic volume control in a multiple stage vacuum tube amplifier employing a multiple grid tube in a stage preceding the final stage which comprises connecting a grid of said multiple grid tube other than the control grid thereof to operate as an anode in a voltage output circuit which impresses upon the said anode-acting grid a positive D. C. potential of pre-determined value, whereby said multiple grid tube of the preceding stage will operate as an electronic coupling device independently of its plate, feeding back signal voltage from the succeeding stage to the plate of said multiple grid tube of the preceding stage so that the said plate and the cathode of said multiple grid tube will function as the elements of a rectifier when, but only when, the peak positive values of feed-back signal voltage from the succeeding stage exceed the value of positive D. C. potential applied to the anode-acting grid of the said multiple grid tube of the preceding stage, and impressing upon the control grid of said multiple grid tube of the preceding stage a pre-determined percentage of the negative D. C. potential appearing at the plate of said multiple grid tube while isolating said control grid from the A. C. component at said plate.

20. A method of accomplishing automatic volume control in a multiple stage vacuum tube amplifier employing a screen grid tube in a stage preceding the final stage which comprises connecting the screen grid of the screen grid tube of said preceding stage to function as an anode in an output circuit for said tube and coupling such output circuit to the input circuit of a succeeding stage, whereby the said screen grid tube of said preceding stage will function as an amplifier independently of its plate, feeding back signal voltage from the output circuit of a succeeding tube to the plate of the said screen grid tube of the preceding stage so that the said plate and the cathode of said screen grid tube will function as a diode rectifier when, but only when, the peak positive values of feed-back signal voltage from the succeeding stage exceed the value of the D. C. potential applied to the screen grid serving as an output anode in said screen grid tube, and impressing upon the control grid of the said screen grid tube of the said preceding stage a pre-determined percentage of the maximum negative D. C. potential appearing at the diode-acting plate of said screen grid tube while isolating said control grid from the A. C. component at the said plate.

21. In a multiple stage electronic amplifier system in which one stage preceding the final stage employs an electronic amplifier having, in

addition to the usual cathode, plate, and control grid, another grid that is electrically closer to the plate than is said control grid, the said other grid of said preceding stage amplifier being connected as an anode in an output circuit that is connected to the input circuit of the succeeding stage in the manner usually assigned to a plate and having impressed thereon a positive D. C. potential of pre-determined value, whereby the said electronic amplifier of the preceding stage and the amplifier system as an entirety will function normally, except for automatic volume control action, independently of the plate of said preceding stage amplifier, means feeding back signal voltage from the output of a succeeding stage to the plate of said electronic amplifier of the preceding stage, whereby rectification will take place between the plate and

5 cathode of said preceding stage amplifier when, but only when, peak values of positive signal voltage exceed the positive D. C. potential impressed upon the said other grid of the preceding stage amplifier, means for applying a pre-determined percentage of the negative D. C. voltage available at the said plate as a result of rectification to the control grid of an amplifier to serve as a volume suppressing bias, said electronic amplifiers of the preceding and succeeding stages being in the nature of electronic vacuum tubes, and the tube of the preceding stage further including a suppressor grid that is closer to the plate than either of the before mentioned grids and is tied to the cathode of said tube.

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