

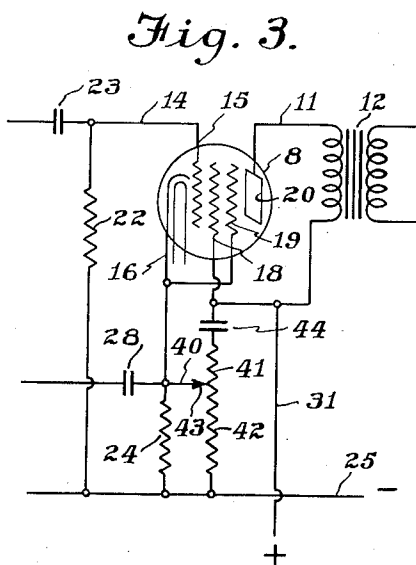
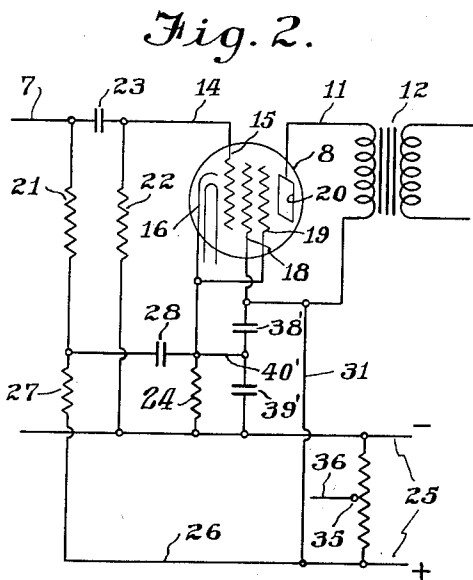
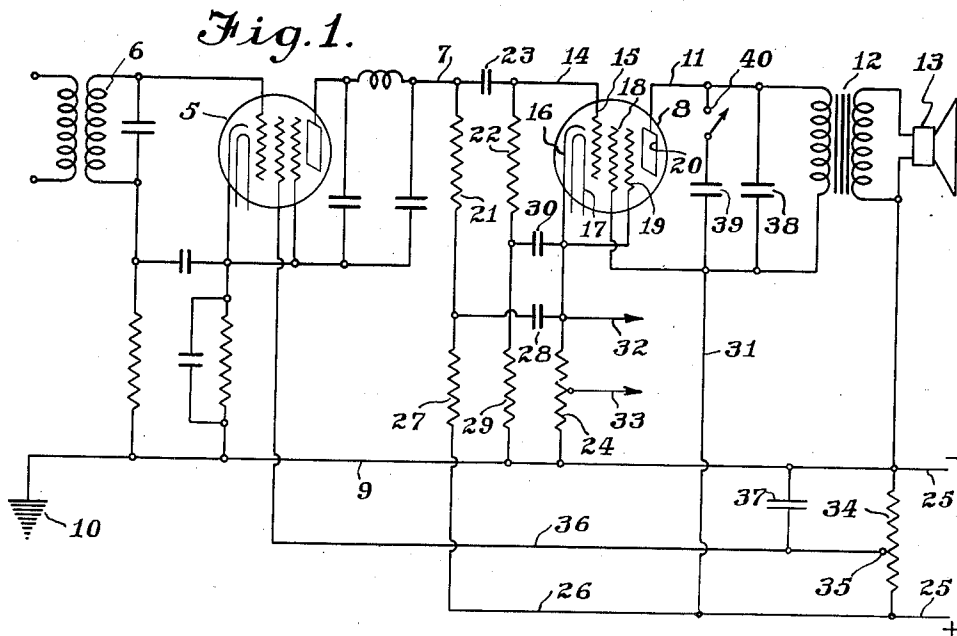
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AMPLIFIER

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AMPLIFIER

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The present invention relates to amplifiers and more particularly to audio frequency amplifiers, of the type employing electric discharge amplifier devices connected in cascade relation in an audio frequency signal channel and supplied with operating potentials from any source providing direct current with a superimposed alternating current ripple voltage, such as current from a rectified alternating current source.

In modern audio frequency amplifying apparatus it is often desirable to employ high gain electric discharge amplifier devices or tubes for minimizing the number of stages required to obtain a predetermined degree of amplification. In a high gain amplifier, impedance coupling is permissible and further lends to a simplification of the amplifier and a reduction in cost of the apparatus.

The elimination of hum voltages and regeneration in impedance coupled and other high quality or fidelity audio frequency amplifiers is particularly difficult, while, at the same time, an impedance-coupled amplifier is particularly desirable because of its frequency response characteristic and low cost, and resistance coupling is preferable because of its low hum pickup characteristic due to lack of inductive elements. These desirable characteristics have been materially outweighed by the additional cost of filter apparatus and circuits heretofore considered necessary to overcome the above and other objectionable features of operation.

It is, therefore, an object of the present invention to provide an improved audio frequency amplifier of low cost which may be given a high fidelity characteristic, as by impedance coupling, and which may at the same time be operated in connection with rectified alternating current supply circuits or other supply circuits carrying a ripple voltage, without being subject to the above and other disadvantages.

It is a further object of the present invention to provide an improved filter circuit in connection with an audio frequency amplifier stage.

The invention will, however, be better understood from the following description when taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing, Fig. 1 is a schematic circuit diagram of an audio frequency amplifier embodying the invention; and

Figs. 2 and 3 are similar circuit diagrams showing a modification of the circuit of Fig. 1.

Referring to Fig. 1, 5 is an electric discharge

detector or amplifier device having an input circuit 6 for receiving signals, and having an output circuit 7 through which the amplified signals are transmitted to a second electric discharge amplifier device 8. A common circuit return lead 9 is provided, and as indicated at 10, this lead may form the ground connection for the apparatus.

The device 5 represents any suitable amplifier stage having an output or anode circuit for coupling with the second amplifier stage including the device 8. The device 8 is an output amplifier in the present example, and is connected through an output circuit 11 and a suitable coupling device such as a transformer 12, with a loud speaker 13 or other device for utilizing the amplified signals.

The device 8 is, in addition, provided with an input circuit 14 and, together with the output circuit and other associated circuits, represents any suitable electric discharge amplifier stage to which the invention may be applied. In the present example, the device 8 is provided with a control grid 15 connected with the input circuit 14, a cathode 16 having a suitable heater 17, a screen grid 18, a suppressor or cathode grid 19, and an output anode 20, the latter being connected with the output circuit 11.

It will be seen that the device 8 is of the screen-grid power pentode type providing a high degree of amplification and may be of the type known commercially as the RCA 2A5.

The device 5 may be an RCA 57 tube, which is particularly adapted for detection of modulated signals in connection with the tuned input circuit 6 as shown, and which also provides a relatively high degree of amplification.

The output circuit 7 of the device 5 is coupled to the input circuit 14 of the device 8 through a suitable high fidelity coupling means, such as an output coupling resistor or anode impedance 21 and input coupling resistor or grid impedance 22, and a coupling condenser 23 providing the usual type of impedance or resistance coupling network.

The amplifier is of the high fidelity, high gain type. Furthermore, it will be noted that the output amplifier 8 is provided with a self bias resistor 24 in circuit with the cathode and is supplied with operating potentials from supply leads indicated at 25, representing any source of operating potentials which may include ripple voltages, and may in the present example be considered as the usual source of rectified alternating current.

With this type of amplifier and circuit, high gain or fidelity is often sacrificed in the interests of hum or regeneration prevention, whereby a compromise in the design of the amplifier must be accepted. In accordance with the invention, however, the high fidelity characteristic and high gain may be retained while using a simple resistor as the bias source, and a rectified alternating current supply, without regeneration or hum ripple characterizing the operation of the amplifier and limiting its usefulness. The resistor is preferably one through which is passed the plate and screen current of the tube 8 or the tube in the second stage of the amplifier. Any other available direct current may also be passed through said resistor to obtain a desired potential drop with a predetermined resistance.

To that end, the output anode circuit 7 of the amplifier stage 5 is connected to the supply source 25 through a supply lead 26, in which is interposed a filter means comprising a series impedance or resistor 27 connected with the output coupling impedance 21, and a bypass capacitor 28 connected between the junction of said impedances 21 and 27 and directly to the cathode 15 of the output stage, to provide an alternating current path of low impedance thereto.

Likewise, the input circuit 14 is also provided with a filter means comprising a series impedance or resistor 29 connected to the ground lead 9 or negative end of the self bias resistor 24, and a shunt condenser element 30 connected between the junction of the input or grid coupling impedance 22 and the filter impedance 29 and the cathode 16.

There are thus provided in each of the coupled circuits between the amplifier stages, namely the output circuit 7 and the input circuit 14, a separate electrical filter comprising a series circuit impedance and an alternating current path comprising a shunt condenser from the circuit to the cathode end of the self bias resistor of the succeeding stage.

The output of the anode circuit 11 for the output tube 8 is supplied with operating current through a supply lead 31 which is connected with the positive side of the supply circuit 25 as indicated. Since the self bias resistor 24 is connected with the lead 9, in turn connected with the negative side of the supply circuit 25, the anode circuit is completed through the self bias resistor 24, as is also the input circuit 14.

Additional operating potentials for other devices, such as the device 5, are taken from a potential supply resistor 34 connected in shunt across the supply circuit 25, a suitable tap and supply lead, together with a bypass capacitor, being provided for such circuits, as indicated by the tap 35, the lead 36, and bypass capacitor 37 for supplying a potential to the tube 5. However, since the tube 5 may be any suitable high gain detector or amplifier device, further description of its circuits does not concern the invention.

The potentials available across the self bias resistor 24 may be utilized in other circuits and may be set up as the result of current flow other than that for the amplifier 8, through suitable connection therewith. Such connection may be provided by circuit leads 32 and 33 and suitable tap points therefor in connection with the resistor 24. In this manner the resistor 24 may serve as a source of potential for other circuits represented by the circuit leads 32 and 33, or may receive current through said leads and the

lead 9 for controlling the bias potential across the resistor 24.

It will also be noted that in parallel with the output circuit 11, and specifically in the present example, in shunt across the input winding of the transformer 12, are provided two tone compensating bypass condensers of relatively low value 38 and 39, the latter being selectively connected across the circuit through a control switch 40. The condensers above described are for the purpose of reducing the high frequency response characteristic of the amplifier to a predetermined desired level.

The operation of the system is as follows: Signals received through the input circuit 6 of the first stage are detected or amplified by the device 5 at a relatively high gain and are transferred through the output circuit 7, across the output coupling impedance 21 to the input coupling or grid impedance 22, through the coupling condenser 23. The device 8 being of the high gain type, signals received through the circuit 14 from the coupling impedance 22 and applied to the grid 15 are highly amplified and are transferred through the output circuit 11 and the output coupling transformer 12 to the utilization circuit or load provided by the loud speaker 13, in the present example.

Any ripple voltage which may be present across the supply circuit 25 is prevented from being impressed upon the tube 8 between the grid 15 and the cathode 16 by the use of the filter 27-28. This connection provides, in effect, an output plate-circuit-to-cathode connection through the condenser 28 at the cathode end of the self bias resistor 24. This connection therefore provides a low impedance alternating current bypass path to the cathode 16 substantially to prevent ripple voltages from the source 25 from reaching the grid 15 through the supply lead 26, the output circuit impedance 21, the coupling condenser 23 and the input circuit 14. Suitable values for the filter elements of the present example are as follows: the resistor 24 may be 800 ohms, the resistor 27 may be 50,000 ohms, and the condenser 23 may be .25 microfarad.

Since the self bias resistor 24 is common to both the input circuit 14 of the amplifier 8 and the output circuit 11, signal generation or regeneration which may tend to be present as a result of the coupling between the two circuits through said resistor is further prevented by the filter 29-30, in addition to the filter 27-28, the former filter effectively isolating the grid circuit from the ground lead 9 and its connection with the self bias resistor 24, and providing a direct alternating current path to the cathode through the condenser 30. Signal voltages across the self bias resistor 24, therefore, are prevented from feeding back to the grid 15 either through the input circuit 14 directly or to said input circuit through said output circuit 7.

Referring now to Fig. 2, in which like parts have the same reference numerals as used in Fig. 1, it will be seen that the output amplifier device 8 is provided with the same input coupling system 21-22-23 together with the filter 27-28 in connection with self bias resistor 24.

In high gain electric discharge amplifier devices in which the screen grid has a relatively high mutual conductance with the plate, ripple voltages present in the supply circuit and supplied to the screen grid with the operating potential therefor, may be transmitted to and appear in the output circuit greatly amplified.

Under such conditions it has been found that a potentiometer means may be provided between the screen grid and the negative side of the supply circuit from which the ripple voltage is taken.

5 In the present example such a potentiometer is provided by two series connected condensers 38' and 39', between which is provided a tap connection 40' directly to the cathode, and thence through the condenser 28 to the output circuit 7.

10 It will be seen that through this connection, ripple voltages present on the screen grid may be transmitted through said connection, the condenser 28, and the input circuit 7, thence through the coupling condenser 23 and the input circuit 14 to the control grid 15. The tap point for the lead 40' between the condensers 38' and 39' is adjusted by providing a proper relation in capacity between the two condensers. In the present example, with a tube of the character described, 20 the condenser 38' may have a capacity of 8 microfarads, while the condenser 39' may have a capacity of 25 microfarads.

By placing an opposing potential on the control grid, the effect of variations in potential on the 25 screen grid are substantially neutralized, thereby preventing the hum or ripple voltage from appearing in the output circuit of the amplifier 8. It will be seen that the filter condenser 28 not only serves, as in the circuit of Fig. 1, to prevent ripple potentials from being supplied to the control grid through the supply circuit 26, but the condenser 28 also serves as the path through which potentials from the screen grid potentiometer means may be applied to the control 35 grid.

The condenser 39' is connected in shunt relation to the self bias resistor 24, whereby the impedance across the resistor 24 is made relatively low as is desirable, the resistor 24 being common to both the input and the output circuits. With this common impedance reduced to a very low value by the condenser 39', signal de-generation therein is prevented. For this reason the grid circuit filter may be omitted, thereby simplifying 45 the apparatus and lowering its cost.

The filter circuit connection provided in the circuit above described serves to introduce a hum ripple on the control grid of such a phase and magnitude that the unavoidable hum components introduced in the screen grid circuit are substantially neutralized.

Through the use of the relatively large bypass capacitor 39' across the self bias resistor 24 and through the use of a relatively large bypass capacitor 38' from the anode and screen grid supply circuit to the cathode, substantially no audio frequency power is dissipated in the self bias resistor 24 and no degeneration is permitted to take place in the screen grid circuit.

60 Referring now to Fig. 3, in which like numerals are used for the same parts as in Figs. 1 and 2, a different form of potentiometer means is shown at 41 and 42, being a simple potentiometer resistor, the two portions of which, as designated on either side of a movable tap 43, correspond to the condensers 38' and 39' of Fig. 2. A stopping condenser 44 is provided to prevent the direct current potentials supplied through the lead 31 from being applied to the cathode 16.

70 By varying the position of the tap 43, and therefore the relative impedance values of the sections 41 and 42, a desired portion of the ripple voltage existing in the circuit 31 may be applied to the cathode 16 and through the cou-

pling condenser 28 to the grid 15, all as described in connection with the preceding figure.

While the bypass condenser potentiometer of Fig. 2 is at present preferred, the potentiometer means in the present embodiment is of a simpler 5 construction and less costly to incorporate in a receiver and, therefore, has that advantage. It is, furthermore, adjustable and represents any suitable adjustable means for the purpose described.

10 While the invention has been described in connection with an impedance coupled amplifier to which it is most effectively applicable, it may be applied to amplifiers having other types of high fidelity coupling means, the essential being that the output or plate circuit of the preceding stage be suitably filtered and bypassed to the cathode side of the self bias resistor in the succeeding stage, and that the input or grid circuit of the succeeding or second stage be provided with a series impedance filter including a bypass alternating current path to the cathode of said second stage amplifier device.

I claim as my invention:

1. An audio frequency amplifier including in 25 combination, a first stage amplifier having an output circuit, a second stage amplifier including a high gain electric discharge amplifier device having an output circuit, and an input circuit for said second stage amplifier coupled to the first named output circuit, a separate self bias impedance for said second stage amplifier common to said input and said last named output circuits of said second stage amplifier only, and a filter for said first named output circuit 30 including a series impedance element therein and a bypass capacitor connected between said first named output circuit and the cathode end of said self bias impedance.

2. An audio frequency amplifier comprising a 40 second stage electric discharge amplifier having input and output circuits, and a self bias resistor common to said circuits only, a first stage electric discharge amplifier having an output circuit coupled to the input circuit of said second stage amplifier for transmitting signals thereto, and means providing an alternating current path between a predetermined potential point on said first stage output circuit and the cathode end of said self bias resistor.

3. An audio frequency amplifier comprising a 50 second stage electric discharge amplifier having input and output circuits and a self bias resistor common to said circuits only, a first stage amplifier having an output circuit coupled to said second stage amplifier for transmitting signals thereto, means providing an alternating current path between a predetermined potential point on said first stage output circuit and the cathode end of said self bias resistor, and a filter for said 60 second stage input circuit including a series impedance device therein and a bypass condenser connected therefrom to the cathode end of said self bias resistor.

4. In an audio frequency amplifier, the combination with an electric discharge amplifier device having a cathode, a control grid, and an output anode, of an input circuit connected with said control grid, an output circuit connected with said anode, a separate self bias resistor for said device connected with the cathode in common to both of and included only in said circuits, a series filter impedance in said input circuit, means providing an alternating current bypass connection from said last-named im- 75

pedance to the cathode, a second electric discharge amplifier device having an output anode circuit coupled to said input circuit to supply signals thereto, a series filter impedance in said
 5 last-named output circuit, and a filter condenser providing an alternating current bypass connection from the anode end of said last-named impedance directly to the cathode of said first-named amplifier device.

10 5. In a multi-stage impedance coupled electric discharge amplifier, a first stage output coupling impedance, a second stage input coupling impedance, separate filter impedances in series with each of said first and second named im-
 15 pedances, a self bias resistor included in circuit with the second stage only, and means providing an alternating current path between the cathode end of said self bias resistor and a point between said impedances in each of said
 20 circuits.

6. A high gain audio frequency amplifier comprising a first stage screen grid electric discharge amplifier device having an output circuit, a second stage screen grid electric discharge amplifier device having an output circuit and having
 25 an input circuit coupled to said first named output circuit for receiving signals therefrom, a separate potential drop producing impedance element connected with the cathode of said second stage amplifier device and in circuit only with
 30 the input and output circuits of said second stage amplifier device for deriving a biasing potential for said second stage amplifier device only, a filter in said first named output circuit comprising
 35 a series high impedance element and a shunt bypass low audio-frequency impedance element connected therefrom to the cathode end of said potential drop producing impedance element, and means providing a low audio frequency impedance
 40 connection from the second stage screen grid to said last named connection point.

7. In an electric discharge amplifier, the combination with a screen grid tube having a cathode,
 45 a control grid, a screen grid and an anode, of impedance coupling means for applying signals to said control grid and including an output anode circuit for a preceding amplifier tube, a filter impedance in said last named circuit, a

filter condenser directly connected from the anode end of said filter impedance to said cathode of the screen grid tube, means providing input and output circuits for said screen grid tube,
 5 a self bias resistor included in said input and output circuits only, adjacent to said cathode, a condenser having relatively low signal impedance connected between the screen grid and the cathode through said self bias resistor, and a potentiometer resistor between said condenser and
 10 said self bias resistor having a tap connection intermediate its terminal ends directly with the cathode of said screen grid tube.

8. An audio frequency amplifier comprising impedance coupled electric discharge devices
 15 characterized by the fact that the anode circuit of one of said devices is provided with a series filter impedance, that the cathode of a succeeding amplifier device is provided with a self-bias resistor common to the input and output circuits
 20 of said device only, and that a by-pass condenser is connected between the anode end of said filter impedance, and the cathode end of said self-bias resistor.

9. An audio frequency amplifier comprising a pair of electric discharge amplifier devices, impedance coupling means between the anode circuit of one of said devices and the grid circuit of the other
 25 of said devices, a self-bias resistor providing a separate source of biasing potential in the cathode circuit of said last named device, and being thereby common to said grid circuit and the output anode circuit only of said device, a filter impedance
 30 in said first named anode circuit, and means providing an alternating current path between the anode end of said filter impedance and the cathode end of said self-bias resistor.

10. A multi-stage audio frequency amplifier embodying electric discharge devices coupled in
 40 cascade relation, characterized by the fact that an anode circuit filter condenser for a preceding stage is connected directly to the cathode of a succeeding stage amplifier device, in circuit with which cathode is provided a self-bias impedance
 45 common to the input and output circuits of said succeeding stage only.

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