Dec. 12, 1933. W. R. KOCH 1,939,398

AMPLIFIER SYSTEM

Filed July 10, 1930

Fig. 1.

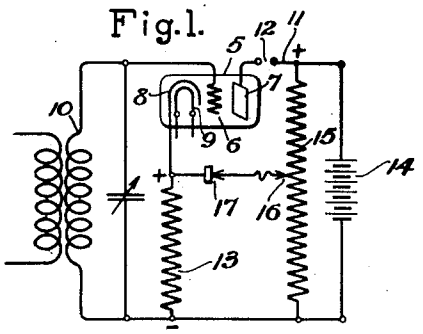


Fig. 2.

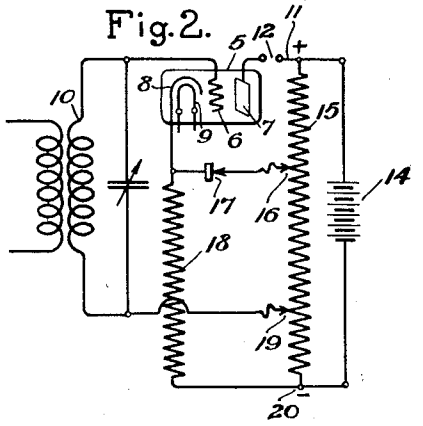


Fig. 3.

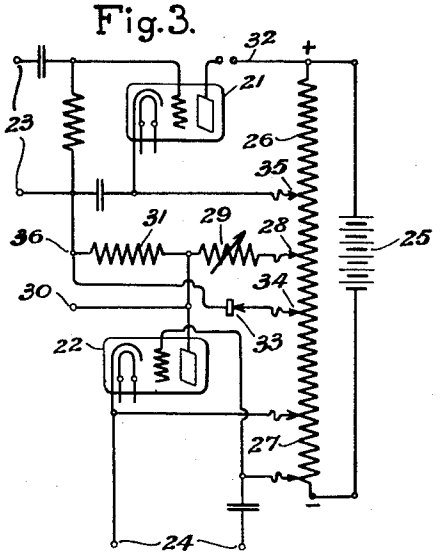
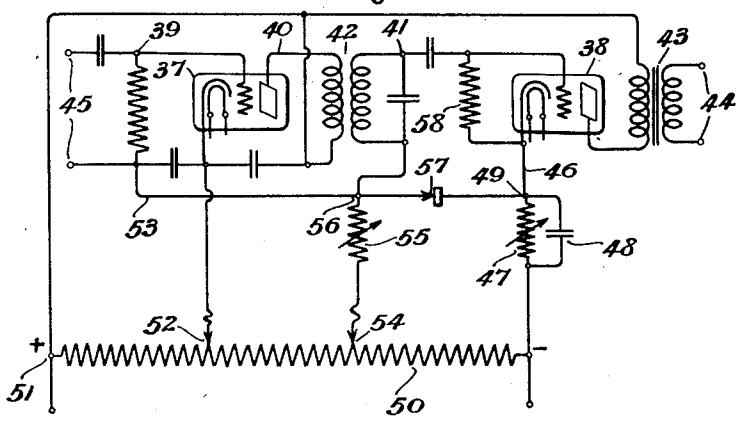


Fig. 4.



INVENTOR.
Winfield R. Koch
BY J. R. Holdsborough
HIS ATTORNEY.

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AMPLIFIER SYSTEM

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

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10 Claims. (Cl. 179—171)

The present invention relates to amplifier systems and the like and, more particularly, it relates to a circuit for controlling the biasing potentials applied to the electrodes of electric discharge devices in systems of the above character, whereby a desired condition of operation of such devices is obtained.

An object of the present invention is to provide an improved circuit arrangement in connection with an apparatus embodying electric discharge devices, whereby a variable bias potential having a pre-determined initial value may be applied to at least one of said devices automatically, in response to a predetermined condition of operation of said apparatus.

A further object of the invention is to provide an improved circuit for controlling the biasing potential applied to a vacuum tube device, such as an amplifier or a detector, whereby, in response to an increase in the strength of an applied signal, overloading of the device may be prevented.

A circuit arrangement, in accordance with the invention, is particularly adapted to the control of the bias potential applied to amplifier devices controlled by automatic volume control circuits responsive to changes in the applied signal strength.

For a further understanding of the invention, attention is now directed to the following description 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 wiring diagram of an electric discharge device of the hot cathode, grid controlled type, provided with a control circuit embodying the invention;

Fig. 2 is a similar wiring diagram showing a modification of the circuit of Fig. 1;

Fig. 3 is a wiring diagram of an electric discharge amplifier, provided with an automatic volume control device and a control circuit embodying the invention; and

Fig. 4 is a further wiring diagram of a particular control circuit embodying the invention, as applied to a radio receiving circuit, including an amplifier and a detector of the electric discharge type.

Referring to Fig. 1, 5 is an electric discharge device of the usual three element type employed in a radio apparatus as a power or plate circuit rectifying type of detector, and having a control grid 6, anode 7, and a cathode 8; the latter, being provided with a heater 9. In the present arrangement, the device is provided with a tuned input circuit 10 connected with its control electrode, an output or anode circuit 11 having terminals 12, and a self bias resistor 13, connected in series with the cathode as indicated, whereby it is common to both the input and the output circuits. Anode or operating potentials are supplied to the anode circuit 11 from a suitable source represented by a battery 14, in parallel with which is connected a potential supply resistor 15. As is well understood, the resistor 15 provides a potential gradient means or divider along which any suitable potential may be obtained by providing a tap thereon, such as a tap 16, in the circuit of the present example.

In the circuit arrangement as shown, radio frequency signals are supplied to the control electrode of the detector through its input circuit 10, and the application of such signals causes an increase in the anode current of the detector. The increased anode current flowing through the bias resistor 13 and as is well known and understood, causes an increase in the negative bias potential applied to the control grid 6.

In a circuit arrangement of this character, when employed in a radio receiving apparatus for example, the detector tube 5 may be overloaded by a strong signal, resulting in distortion and possible injury to associated apparatus. Accordingly, there is provided in connection with a circuit of this character, means for preventing overloading the detector, which represents any electric discharge device of this character. This includes the self bias resistor 13 and a connection from the source whereby the biasing potential applied to the control electrode 6 is maintained above a certain predetermined negative value in the absence of signals, but is permitted to increase in a normal manner upon the reception of signals.

To this end, there is provided a connection between the tap 16 on the voltage supply resistor of voltage supply source and the cathode or positive end of the self bias resistor 13, and interposed between these two points, is a suitable rectifying device 17, which permits the flow of current in the direction of the arrow toward the cathode. The rectifier is represented as being of the contact type, although any suitable rectifier device may be employed. Rectifier devices commonly known as the copper oxide type, have been employed and found to be suitable for this use.

It will be noted that the tap 16 is adjustable, and in operation is adjusted to such a point upon the supply source 15 that under a condition of static operation as when no signals are being

applied to the detector 5 through the input circuit 10, the positive potential existing at the point 16 exceeds the potential applied to the cathode that is, the potential which exists at the cathode or positive end of the self bias resistor 13. Under this condition of operation, current flows from the point 16, through the rectifier device 17, to said cathode end of the bias resistor 13, thence through said resistor 13 and returns to the negative side of the supply source. The flow of current through the resistor 13 causes a drop in potential, sufficient to provide the desired static negative bias potential upon the control electrode 6.

Upon receiving a signal through the input circuit 10, the anode current of the detector 5 increases, causing an increase in the flow of current through the bias resistor 13 and a corresponding increase in the bias potential set up by the potential drop therethrough. As the signal strength increases, the anode current increases correspondingly, and the value of the resistor 13 is such that the increased potential drop is sufficient to set up the desired increased bias potential, whereby the tube is made to operate properly as a detector in the presence of strong signals.

It will be seen that when the bias potential set up by the anode current flow through the bias resistor 13 equals or exceeds the value of the potential supplied by the source 15 through the tap 16, no further current will flow from the source of supply, and the operation of the tube and the application of biasing potential will then automatically be controlled by the flow of anode current in the usual manner. The circuit arrangement thus provided operates to set up a fixed bias potential across the self bias resistor 13 whenever the signal voltage drops below a pre-determined value, thereby to provide a predetermined fixed bias potential upon the electric discharge device or detector 5.

A circuit arrangement of this character has the advantage that it is applicable to the usual form of bias or plate rectifying detector now used extensively in radio receiving apparatus, by providing merely an adjustable tap point upon the voltage supply source or resistor 15 and a connection therefrom to the cathode end of the self bias resistor 13, through a simple rectifier device having a polarity such that it will pass current when an unbalanced voltage exists on one side of it.

It will be noted that the circuit arrangement is such that the bias resistor is connected in the anode circuit of an electric discharge device, preferably in the cathode return lead, whereby it is also in the input or grid circuit. Anode current is thereby supplied to said resistor to set up a biasing potential, responsive to the changes in the value of signals supplied to said device through its input circuit. Connected in parallel with said resistor, is a source of potential of a pre-determined fixed value in series with a rectifier device so poled that the current from said fixed source may flow therefrom through the self bias resistor only in one direction, and that, in the direction to maintain a certain fixed bias potential across said bias resistor.

Referring now to Fig. 2, in which the same reference numerals are employed for like parts as appear in Fig. 1, a self bias resistor 18 for the detector tube 5 of relatively high value is provided whereby it is made more sharply responsive to an increase or changes in the value of the anode current as a result of changes in the signal strength, to more rapidly change the bias on the tube. In addition, the input circuit 10 is connected to a second tap point 19 on the supply source 15; whereby in series with the input circuit 10 and in connection with the control electrode 6, there is provided an opposing potential between point 19 and a point 20 on the supply source for in part opposing or counteracting the negative bias set up by the self bias resistor 18. Since the bias resistor 18 is of a higher value, the potential drop supplied by it is, therefore, greater and, accordingly, for a static condition of operation, a compensating potential is applied as by the arrangement above described.

The tap point 16 is connected with the cathode end of the self bias resistor 18 through the rectifier 17 in the same manner as in Fig. 1, and the remainder of the circuit is the same. The circuit of the present example has the advantage that a self bias resistor 18 may be employed which is larger than that normally employed; whereby, the bias control of the electrode 6 is rendered more readily responsive to changes in signal strength, since a relatively small change in anode current through it may cause a relatively wide change in the value of the bias potential supplied to the control electrode 6. At the same time, for a static condition of operation with no signal supplied, the additional neutralizing voltage supplied between points 19 and 20 on the supply source, serves to cause a normal operation of the device, that is, a normal static bias potential between the cathode and the point 19. The value of the bias potential supplied by the bias resistor 18 less than between points 19 and 20 is such that with a static condition of operation wherein no signals are supplied, the anode current of the device is reduced substantially to zero.

Referring now to Fig. 3, 21 is an amplifier tube which is controlled by a volume control tube 22. These tubes are electric discharge devices of the type employed in the circuits of the preceding figures and are provided with signal input or grid circuits indicated at 23 and 24 respectively. The operating potentials are supplied from a source 25, provided with a tapped voltage supply resistor 26, similar to that provided in the preceding examples. The polarity of the source is indicated by symbols located adjacent its terminals. The volume control tube receives its bias potential from a portion 27 of the supply source 26, and its anode potential from a tap 28, in connection with the source 26.

In the anode circuit of the volume control tube, there is provided a coupling resistor 29, from which controlling potentials may be taken for any purpose through a lead and a terminal indicated at 30. In the present example, there is also connected with the coupling resistor 29 the grid or input circuit of the amplifier tube 21. This connection is made through a resistor 31 which is of relatively higher value than resistor 29. With this circuit connection, when signals are applied to the input circuit 24 of the volume control tube 22, in response to a change in the strength of said signals, a variable D. C. bias potential corresponding thereto is placed upon the control electrode of the tube 21, thereby controlling its output in response to the signal strength. The potential or terminal 30, is also similarly controlled. Signal or volume control circuits of this general character are known and well understood, hence further description

of this phase of its operation is believed to be unnecessary.

As is obvious, the strength of the signals applied to the volume control tube 22 may often be such that the amplifier device or tube 21 may be biased to a relatively high negative value, sufficient to cause distortion in operation. In this connection it will be noted that this circuit arrangement is similar to that shown in Figs. 1 and 2, in that a resistor is provided in the anode circuit of an electric discharge device such as the tube 22, through which a variation in anode current is set up by a variation in the strength of signals applied to the tube. However, the potential set up by the variation in the flow of anode current is not applied to the control electrode of the same tube as in Figs. 1 and 2 but to the control electrode of another or amplifier tube 21, thereby to control the flow of signal energy through another circuit in the flow of signal energy from the input circuit 23 of the amplifier 21 to the output or anode circuit 32. For purposes of simplifying the drawing, output devices in the anode circuit 32 are omitted as in the anode circuits shown in the preceding figures.

Furthermore, in the circuit of Fig. 3, there is provided in parallel with the bias connection through the resistor 31, a parallel connection with the grid or control electrode circuit through a rectifier device or valve 33 to a source of potential provided by a tap point 34 on the source of potential 26. This tap point 34 is in spaced relation to a cathode connection 35 for the device 21, whereby, with respect to the cathode of device 21, there is placed upon the tap point 34 and upon its connected rectifier device 33, a negative potential. It will be seen that the arrangement is such that this negative potential is poled in opposition to the negative potential provided by the coupling resistor 29 and applied to the control electrod circuit of tube 21 through the resistor 31.

The tap point 34 is so adjusted that a negative potential is applied to the rectifier device 33, such that as the potential applied by the coupling resistor 29 is varied in response to an increase in signal strength applied to the control tube 22, a point is reached whereat a balance in potential is obtained upon the control electrode circuit at the point indicated at 36. Beyond that point, the negative potential applied to the amplifier tube 21 tends to remain constant because the unbalanced effect of the further increase in the negative potential supplied by the coupling resistor 29 causes a flow of current through the rectifier in the direction of the arrow, to cause an opposing potential to be set up by a potential drop in the resistor 31 which, being relatively large, is correspondingly highly effective. The resistor 31 also serves to isolate the output or control circuit 30 of the volume control tube from the grid or control electrode circuit of the amplifier device 21.

From a consideration of the foregoing, it will be seen that an anode circuit or coupling resistor is provided in connection with one electric discharge device and is connected to supply a biasing potential to the input or control electrode circuit of another electric discharge device or tube and that a source of biasing potential is provided for the input or control electrode circuit of the last named device and is connected with said circuit through a rectifier device. The rectifier device is adapted to pass current in a direction whereby a substantially constant biasing potential is applied to said input or control electrode circuit when the value of said potential reaches or exceeds a pre-determined value. By this arrangement, the amplifier device 21 may be caused to operate in such a manner that its anode current will not be reduced to such a low value that it will cause distortion in the transmission of signals through it.

It will be noted that the terminal 30, being directly connected with the anode circuit of the volume control tube is directly controlled thereby independently of the control exercised by the rectifier and the resistor 31 over the amplifier tube 21.

Referring now to Fig. 4, electric discharge devices 37 and 38 are connected with a radio receiving circuit to provide, respectively, a radio frequency amplifier and a detector of the grid-leak and condenser type. The radio frequency amplifier device or tube 37 is provided with an input or grid circuit 39 and its output or anode circuit 40 is connected with the input or grid circuit 41 of the detector 38 by a suitable coupling transformer 42. The detector is provided with an output device 43, having output terminals 44. The arrangement is such that radio frequency signals supplied to the input circuit 39 from the input terminals 45 are amplified by the device 37 and applied to the detector 38, wherein they are rectified by the grid leak and condenser method and supplied as rectified signals to the output terminals 44.

The cathode return circuit 46 of the detector 38 is provided with a series resistor 47, shunted by a suitable audio frequency by-pass condenser 48, whereby, in the absence of signals being applied to the detector, a pre-determined positive potential is set up at the cathode end 49 of the resistor 47 by reason of the flow of anode current therethrough. The anode current is derived from any suitable source, such as that indicated at 50. In the present example, the detector anode circuit is connected across the terminals of the source.

The anode circuit of the amplifier device 37 is connected to one terminal 51 of the source and a tap point 52. The polarity of the source is indicated by polarity marks adjacent thereto. It will be noted that the grid or input circuit of the amplifier device 37, is connected through a potential supply lead 53 with a tap point 54 upon the source 50 which point is more negative than the tap point 52 for the cathode thereof, whereby a negative bias potential is placed upon the amplifier device 37 for its proper operation.

A series resistor 55 is provided in the bias potential supply lead 53 and by adjustment of the tap point 54 and the resistor 47 the point 49, or cathode end of the resistor 47, is made more positive than the point 56, or grid end of the resistor 55. Between these two points, there is connected a rectifier device 57 so poled that it prevents a flow of current from point 49 to point 56, but allows current to flow in the opposite direction when there is a change in the potential balance above described.

Under a static condition of operation, with no signal being transmitted through the amplifier and detector, the detector anode current flowing through resistor 47 is sufficient to set up a potential drop which causes the point 49 to remain more positive than the point 56. In other words, the anode current of the detector through the resistor 47 serves to control the potential applied to one side of the rectifier device 57,

and is such that being higher than that applied to the opposite side and by reason of the polarity of the rectifier, no current flows through the rectifier. Hence, the bias potential applied to the amplifier device 37 is only that set up between the tap points 52 and 54 on the voltage supply source 50, and is the normal bias required to hold the anode current of the amplifier device at a normal value for normal or maximum amplification.

When a strong signal is received the anode current of the detector 38 decreases in value in proportion to the strength of the signal. The potential drop in the resistor 47 becomes proportionately lower. Therefore, the point 49 finally becomes more negative than the point 56. In other words, an unbalance of the potential existing on opposite sides of the rectifier device is set up in a reverse direction from that normally set up under a static condition of operation. The direction of unbalance is such that current is caused to flow through the rectifier in the direction of the arrow.

The current flow is caused by the potential at point 54 on the source and, in flowing through resistor 55 thence through the rectifier and returning through the resistor 47, this current causes a drop in potential in the resistor 55.

It will be seen from the polarity of the supply that this drop in potential is in a direction such that it is added to the fixed bias potential supply to the amplifier 37 between points 52 and 54, whereby it operates to reduce the amplification provided by said device and prevents the signal from overloading the detector and other associated apparatus. It will be noted that the detector grid circuit is returned to the cathode directly through the leak resistor indicated at 58.

From the foregoing description it will be seen that in a radio receiving apparatus embodying electric discharge devices, the application of a signal to one of said devices is caused to control the biasing potential applied to another of said devices, in accordance with the strength of the applied signal, through the medium of an impedance in the anode circuit of the first of said electric discharge devices and a second impedance device in the control electrode or input circuit of the second named device, and a rectifier device arranged to connect the circuits in which said impedances are located at points of differing potentials, the arrangement being such that in response to an increase in signal strength or in response to an applied signal, the potentials then existing on opposite sides of the rectifier device are unbalanced in a direction to cause current flow therethrough, thereby changing the bias on the second named device and reducing the strength of the signals transmitted therethrough.

It will be seen that in accordance with the invention there may be provided in connection with an electric discharge device a source of biasing potential of any suitable form such for example as a self bias anode circuit resistor or a fixed source of biased potential provided with a series resistor, and in connection with either of these types of potential supply for biasing or control purposes there may be provided a second source of biasing potential and connected with the first through a rectifier device and the second named resistor.

With a bias control system of this character, the normal biasing circuit for an electric discharge device may be completed through any suitable means including a resistor to which additional potentials may be applied from a source of varying potentials responsive to changes in the signal strength applied to the apparatus, a rectifier device being provided to connect the last named source with the resistor.

It will be seen that the application of this system is not limited to the circuits shown, but may be applied to other circuits requiring the control of electric discharge devices substantially in the same manner.

I claim as my invention:

1. The combination with an electric discharge device, of means for applying biasing potentials thereto, said means including at least two sources of potential one of which is variable, and a rectifier device bridged across between said sources for transmitting current between them when the potential of said variable source reaches a predetermined value.

2. In a radio apparatus, the combination with an electric discharge device having a control electrode, an anode and a cathode, of means responsive to a signal wave for applying a bias potential to the control electrode, and a second means including a source of potential and a rectifier bridged across between said source and said first named means, for applying a second biasing potential to said electrode.

3. The combination with an electric discharge device having a cathode and a resistor connected in circuit with said cathode for applying a biasing potential thereto, of means providing a source of potential, and a rectifier device bridged across between said source and the cathode end of said resistor, said rectifier device being so poled that current may flow therethrough from said source in the direction of said resistor.

4. The combination with an electric discharge device having a control electrode, a cathode and a control circuit connected between said electrodes, of a self bias resistor connected in said circuit, and a second circuit connected in parallel with said resistor, said second circuit including a rectifier device and means adapted to provide a source of potential, said rectifier device and said source of potential being so poled and connected that current may flow through said rectifier device to control the biasing potential applied to the control electrode.

5. In a radio receiving apparatus, the combination of an amplifier device having a control electrode and a cathode, a signal circuit connected to said control electrode, and a resistor connected between the cathode and the control electrode, means for applying a biasing potential to the control electrode through said resistor, a second electric discharge device adapted to receive signal current from said first named device and having an anode circuit, a resistor in said anode circuit, and a rectifier device connected in circuit between said resistors.

6. The combination with an electric discharge device having a control electrode, an anode and a cathode, of means connected with said control electrode for applying a biasing potential thereto, a second means adapted to provide a source of potential, and a rectifier device connected between said first and second named means whereby it is subjected to opposing potentials, said device being so poled in circuit between said potential supply means that current may flow therethrough in a direction to apply a resulting biasing potential to the control electrode of a desired value differing from that applied by the first named means.

7. In a radio receiving apparatus having an amplifier including a tube provided with a control grid, and a volume control tube having an anode circuit, of a coupling resistor in said anode circuit, means providing a connection between the control grid of the first named tube and said coupling resistor, a second resistor in said connection, a rectifier device connected with said control grid in parallel relation with the second named resistor, and means providing a source of fixed potential in circuit with said second named resistor and rectifier device.

8. In a radio receiving apparatus, the combination with a detector tube having an anode circuit, an amplifier tube having a control grid circuit and means for transmitting signal energy from said amplifier tube to said detector, of a source of biasing potential connected with said control grid circuit, a resistor in said connection, a second resistor in the anode circuit of the detector, a source of potential and circuit means for transmitting current through said resistors, and a rectifier device connected between said resistors to control the flow of current therethrough.

9. The combination with an electric discharge device having an anode, a cathode and a control electrode, of means providing a source of anode potential therefor, a self bias resistor connected adjacent to and in circuit with said cathode, and a rectifier device connected between said cathode and a point on said source of potential for transmitting current therefrom to said self bias resistor.

10. The combination with an electric discharge device having an anode, a cathode and a control electrode, of means providing a source of anode potential therefor, a self bias resistor in circuit with said cathode, a rectifier device connected between said cathode and a point on said source of potential for transmitting current therefrom to said self bias resistor, and means providing an input circuit between the control electrode and a second point on said source of anode potential.

WINFIELD RUDOLPH KOCH.