May 12, 1942. C. S. ROOT 2,282,380

FEED-BACK CIRCUIT

Filed July 26, 1938

Fig. 1.

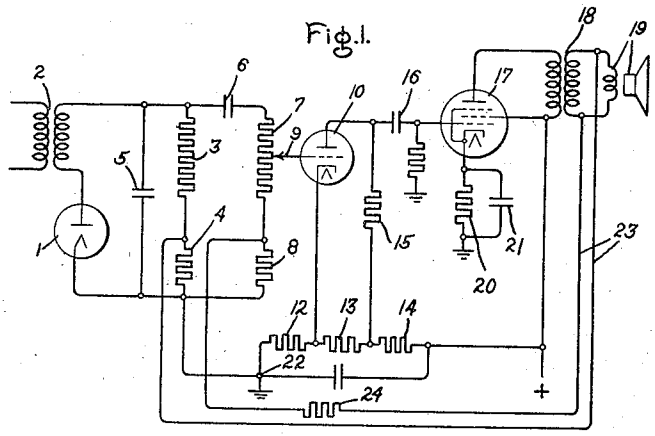


Fig. 2.

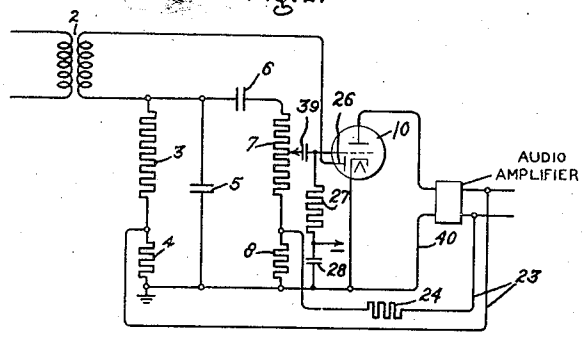
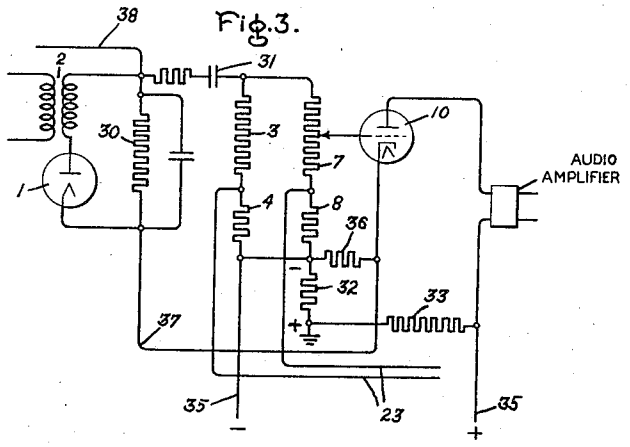


Fig. 3.



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UNITED STATES PATENT OFFICE

2,282,380

FEED-BACK CIRCUIT

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Application July 26, 1938, Serial No. 221,319

10 Claims. (Cl. 179—171)

My invention relates to feed-back circuits for electron discharge devices, and more particularly to such circuits employing means to vary simultaneously the volume of electromotive force supplied for transmission through the discharge device and the magnitude of the feed-back voltage.

In application Serial No. 166,292, filed September 29, 1937, by William S. Bachman, entitled Audio frequency amplifier system, and which is assigned to the same assignee to which my present application is assigned, is disclosed an audio amplifier employing a degenerative feed-back system in which the magnitude of the feed-back voltage is automatically reduced upon movement of the manual volume control to increase the application of signal electromotive force to the amplifier. In this way, when the manual volume control is in a position for maximum sensitivity to voltages to be amplified, as when used in a radio receiver, the degeneration is automatically reduced.

One of the objects of my invention is to provide certain improvements upon systems of the type described in said Bachman application and more particularly to provide means whereby the feed-back voltage may be reduced to zero upon a certain adjustment of the volume control for high sensitivity. A further object of the invention is to provide means whereby the feed-back voltage may be automatically reversed upon movement of the volume control to positions of still higher sensitivity.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the following drawing in which Fig. 1 represents an embodiment of my invention, and Figs. 2 and 3 represent modifications thereof.

Referring to Fig. 1 of the drawing, I have represented therein at 1 a diode which may be the diode detector of an ordinary radio receiver. Electromotive forces to be detected by the diode 1 are supplied thereto by a transformer 2. The detector operates into a load resistance comprising resistors 3 and 4 across which are connected the usual condenser 5. In parallel with the resistors 3 and 4 is a path comprising condenser 6, potentiometer 7 and resistance 8, the variable element 9 of the potentiometer being connected to the grid of an electron discharge device 10. The cathode of this discharge device is connected to a point on the bleeder resistance of the rectifier which supplies operating potential to the discharge devices of the system, this bleeder resistance comprising sections 12, 13, and 14. The anode of discharge device 10 is connected through anode coupling resistor 15 to the bleeder resistance at a point between resistances 13 and 14. Oscillations appearing in the output circuit of the discharge device 10 are supplied through a coupling condenser 16 to the control grid of a second electron discharge device 17, the output of which is supplied through a transformer 18 to a loud speaker 19.

Resistance 20 shunted by condenser 21 is connected between the cathode of discharge device 17 and ground for bias purposes, the anode thereof being connected through the primary of transformer 18 to the positive side of the source of operating voltage, the negative side of which is grounded as indicated at 22.

Conductors 23, one of which includes resistance 24, form a circuit extending from the output of discharge device 17 to points respectively upon the two parallel paths, one of which comprises resistances 3 and 4 and the other of which comprises resistances 7 and 8, the respective points being between these resistances, this circuit comprising the feed-back circuit utilized to produce degeneration or regeneration in the system.

The two paths 3, 4, and 6, 7, and 8 constitute a Wheatstone bridge, the resistances 3 and 4 being the ordinary diode load and having impressed thereon the rectified signal electromotive force, which may be the ordinary audio voltages produced in the diode circuit of a radio receiver. The resistances in these paths 3, 4, and 6, 7, 8 are so proportioned that these paths comprise a Wheatstone bridge, the two conductors 23 being connected at diagonally opposite corners of the bridge. The cathode of the discharge device 10 is connected through resistance 12 and ground to a third diagonally opposite corner of the bridge which is likewise connected to the cathode of the diode 1. The grid of discharge device 10 is connected to a tap 9 on potentiometer 7 whereby this connection may be moved along resistance 7. When it is in its lower position a small portion of the voltage produced by the diode 1 is supplied to the discharge device but a maximum amount of the voltage supplied by the feed-back conductors 23 is supplied to the grid of the discharge device. As the contact 9 is moved upward the portion of the voltage produced by the diode which is supplied to the grid of the discharge

device is decreased. The arms of the bridge may be so proportioned that when the contact 9 is in its extreme upper position the bridge is exactly balanced. The system is then adjusted for maximum transmission of signal energies produced by the diode 1 and for zero feed-back. Since the voltage produced by the conductors 23 is supplied to the bridge in phase to produce degeneration it will be observed that in this position of the contact 9 the system has maximum sensitivity.

Degenerative feed-back systems as used in audio amplifiers are extremely important by reason of their improvement of the frequency characteristics of the amplifier to which they are applied, their reduction of hum, and their correction of distortion. Since the degeneration however, has the effect of reducing the sensitivity of the amplifier, or of reducing the amplification of the discharge device, it is important that the degeneration be completely removed when maximum amplification is required as upon reception of extremely weak signals in the radio receiver. At such times the contact 9 is moved to its upper position in order that all of the audio signal electromotive force available may be supplied to the discharge device. In accordance with my invention in which the diode load 3, 4 and the potentiometer circuits 6, 7, 8 are connected with respect to the diode and to the feed-back circuit in bridge relation, this feed-back voltage may be reduced to zero when maximum amplification is required.

In fact, it has been found that by properly proportioning the bridge, the point of contact 9 upon resistance 7 where zero feed-back voltage is supplied to the grid, may be adjusted to a point short of the top of the resistor; that is, to a point intermediate the ends of the resistor. In this way, as contact 9 is moved upward from the bottom of the resistor, the degenerative voltage is reduced until a point is reached where it is zero. Upon further movement of the contact 9 upward this voltage is reversed in phase and becomes regenerative so that it tends to increase the amplification of the amplifier by reason of regeneration. Such increased amplification which occurs at adjustments of the contact on the potentiometer utilized only upon reception of weak signals is, of course, valuable. In such an arrangement I have employed a resistance 3 of 3,900,000 ohms; resistance 4 of 220 ohms, resistance 7 of 2,000,000 ohms, and resistance 8 of 22 ohms.

It will be seen that these results are secured without any appreciable complication of the circuits. The only resistance added to that of the system of the above referred to Bachman application is the resistance 4 which may be of ten ohms; that is, I have utilized a ten-ohm resistor in this position in a system where resistance 3 was one of 200,000 ohms, resistance 7 of 2,000,000 ohms, and resistance 8 of 100 ohms for exact balance at top of potentiometer 7.

By reason of the balance of the bridge, as thus explained, no degenerative voltage from conductor 23 exists across the diode branch of the bridge. This is very desirable since such voltage would react on the diode causing it to operate at a different level and would result in distortion.

The magnitude of resistance 24, of course, determines the amount of feed-back voltage. While this resistance may be variable it is commonly fixed and I have found a value of 220 ohms satisfactory.

Fig. 2 differs from Fig. 1 principally only in that the audio amplifier 10 is one of the multifunction type in which the diode is arranged within the envelope of the audio amplifier and comprises the cathode of the audio amplifier plus an additional anode 26. Also the amplifier in this case obtains its bias through the resistor 27 from a suitably negative point 40 of the circuit, which is by-passed by condenser 28. The condenser 39 prevents resistors 7 and 8 from having any effect on this bias. The remaining amplifier I have designated on the drawing by a rectangle bearing the legend "audio amplifier."

It may be desirable at times in the application of my invention to remove the direct current of the diode detector load from the bridge. Accordingly, in Fig. 3 the diode load comprises a resistance 30, separate and apart from the bridge. The alternating current voltage of this resistance is supplied through coupling condenser 31 to the two parallel paths of the bridge comprising resistances 3, 4, and 7, 8. Feed-back conductors 23 are connected to the bridge in the usual way. Resistances 32 and 33 comprise the usual bleeder resistance connected across the usual power supply conductors 35. The resistance 36 operates to maintain the grid of the discharge device 10 at negative potential with respect to its cathode. Potential is also supplied through resistances 32 and 36, conductor 37 and diode load resistance 30 to conductor 38 by which it may be supplied to the grids of the radio frequency amplifier of the preceding circuits of the receiver for normal bias purposes, this bias, of course, being increased by the potential on resistance 30, when signals are received, for automatic volume control purposes.

Since the diode 1 and discharge device 10 have their cathodes connected to the same point it is obvious that they may be replaced by a single combination diode and amplifier tube having a common cathode.

While I have shown particular embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto since different modifications may be made both in the circuit elements and in the instrumentalities employed and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States:

1. In combination, an electron discharge device having input electrodes, and an output circuit, a Wheatstone bridge, means to supply electromotive force to be transmitted through said discharge device to one pair of diagonally opposite corners of said bridge, and means to supply electromotive force from said output circuit to another pair of diagonally opposite corners of said bridge, the input electrodes of said discharge device being connected between one of said first pair of corners and an arm of said bridge.

2. In combination, an electron discharge device having input electrodes, and an output circuit, a Wheatstone bridge, means to supply electromotive force to be transmitted through said discharge device to one pair of diagonally opposite corners of said bridge, and means to supply electromotive force from said output circuit to another pair of diagonally opposite corners of said bridge, one of said input electrodes being

connected to one of said first diagonally opposite corners of said bridge and the other input electrode being connected to a variable point on an arm of said bridge, said point being movable between one of said second pairs of diagonally opposite corners and the opposite one of said first mentioned diagonally opposite corners.

3. In combination, an electron discharge device having input electrodes, a potentiometer, means to supply signal oscillations across said potentiometer, said input electrodes being variably tapped from said potentiometer, thereby to vary the portion of said signal oscillations on said potentiometer supplied to said input electrodes, an output circuit, means to supply voltage from said output circuit to said input electrodes to produce degeneration, and means to produce said degeneration when said potentiometer is adjusted at one position and to produce regeneration when said potentiometer is adjusted at another position.

4. In combination, an electron discharge device having input electrodes, a source of electromotive force to be transmitted through said discharge device, a volume control potentiometer, said input electrodes being connected across a portion of said variable potentiometer to vary the electromotive force of said source supplied to said discharge device, and means to supply voltage from the output circuit to said input circuit in degenerative phase when said input electrodes are connected across a small portion of said potentiometer and in regenerative phase when said input electrodes are connected across a large portion of said potentiometer.

5. In combination, a source of electromotive force, an electron discharge device having an input electrode connected to one point on said source and another input electrode connected to a point variable along said source to vary the electromotive force applied between said electrodes, an output circuit for said discharge device; means to supply electromotive force from said output circuit between said input electrodes, and means responsive to movement of said variable point along said source to reverse the phase of said electromotive force supplied from said output circuit as applied between said input electrodes.

6. In combination, a source of electromotive force, two parallel paths connected thereacross, an electron discharge device having an output circuit, a connection between two intermediate points on said paths, input electrodes for said electron discharge device, one of said input electrodes being connected to one side of said source, and the other input electrode being connected to a point movable along the portion of one of said paths adjacent the opposite side of said source, and means to supply voltage to said connection from said output circuit, said voltage being supplied in degenerative phase to one of said points and in regenerative phase to the other of said points.

7. In combination a source of electromotive force, two parallel paths connected thereacross, an electron discharge device having an output circuit connected between two intermediate points respectively on said paths, and having input electrodes, one of said input electrodes being connected to one side of said source, and the other input electrode being connected to a point movable along the portion of one of said paths adjacent the opposite side of said source whereby the portion of the electromotive force of said source supplied between said electrodes is variable by movement of said point along said path, the phase of the voltage supplied from said output circuit being degenerative as supplied between said electrodes, and said paths being so proportioned that no voltage from the output circuit appears between said electrodes when the point to which said other electrode is connected is such that a large portion of the voltage of said source is supplied to said input circuit.

8. In combination, a source of electromotive force, two parallel paths connected thereacross, an electron discharge device having an output circuit connected between two intermediate points respectively on said paths, and having input electrodes, one of said input electrodes being connected to one side of said source, the other input electrode being connected to a point movable along the portion of one of said paths adjacent the opposite side of said source whereby the portion of the electromotive force of said source supplied between said electrodes is variable by movement of said point along said path, the phase of the voltage supplied from said output circuit being degenerative as supplied between said electrodes, and said paths being so proportioned that no voltage from the output circuit appears between said electrodes when the point to which said other electrode is connected is such that a large portion of the voltage of said source is supplied to said input circuit, and is in regenerative phase when said point is moved to increase the portion of the electromotive force of said source supplied between said electrodes.

9. In combination, a diode detector, an audio amplifier to amplify signals detected by said diode detector and a Wheatstone bridge connected between said diode detector and amplifier, said diode detector being connected between diagonally opposite points of said bridge, means to supply voltage from the output of said amplifier between the other pair of diagonally opposite points of said bridge, and the input of said amplifier being connected between one of said first diagonally opposite points and an arm of said bridge whereby said voltage supplied from said output circuit is impressed on said amplifier input in degenerative phase and is prevented from affecting said diode by reason of the balance of said bridge.

10. In combination, a diode detector, an electron discharge amplifier to amplify signals detected by said detector, and having a cathode and input electrode, a bridge having two diagonal branches, one of said branches including said diode detector, and the other of said branches including the output of said amplifier, the cathode of said amplifier being connected to the terminus of said one branch adjacent the cathode of said diode and said input electrode being connected to an intermediate point on an arm of said bridge whereby voltage from the output of said amplifier is supplied to said input and is prevented from affecting said diode detector by reason of the balance of said bridge and said cathodes are at the same potential.

CHARLES S. ROOT.