

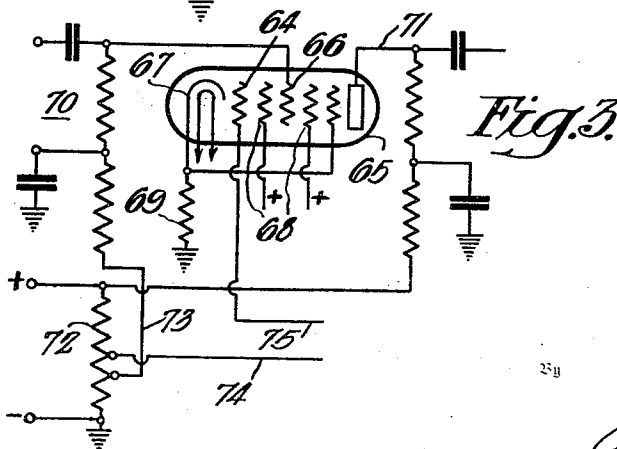
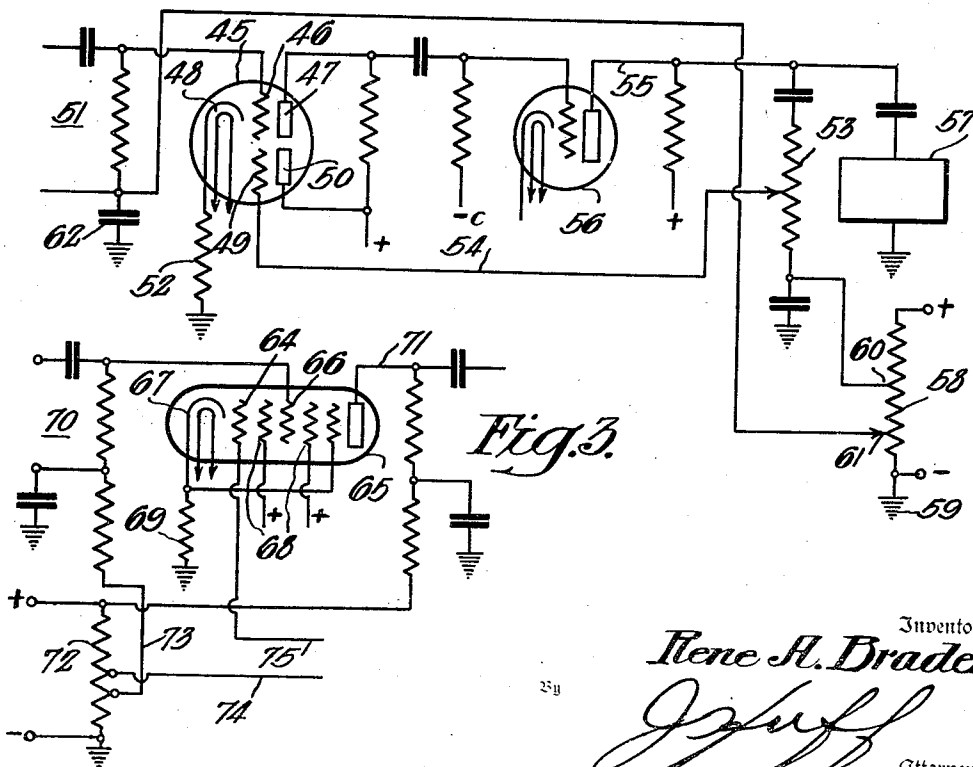
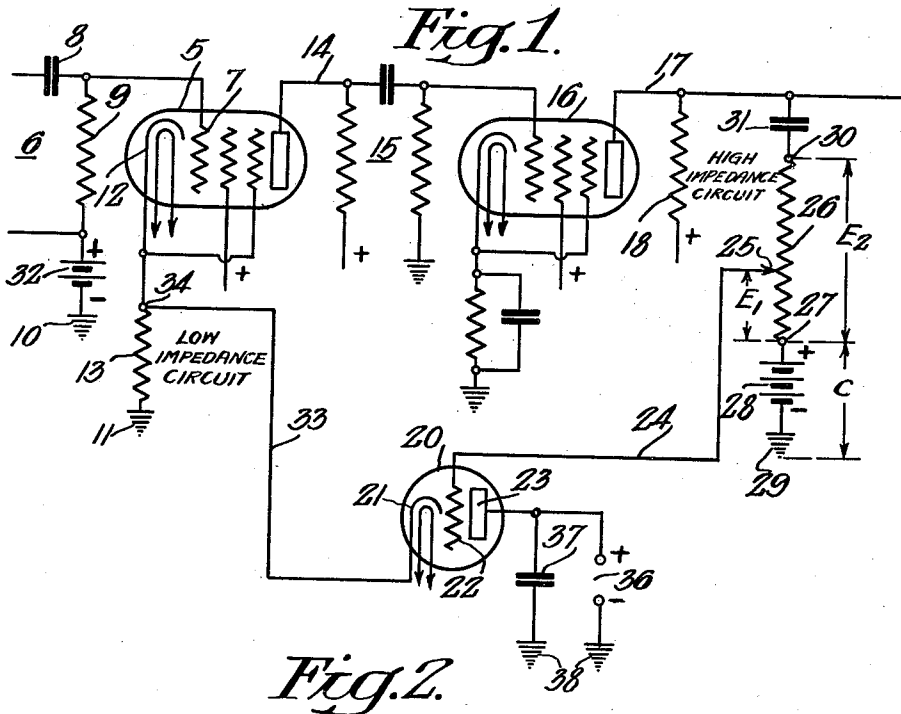
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INVERSE FEEDBACK AMPLIFIER

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INVERSE FEEDBACK AMPLIFIER

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The present invention relates to inverse feedback amplifiers wherein a portion of the output voltage is fed back to the input circuit through a separate feedback circuit, in opposition to the input voltage, and has for its object to provide an amplifier of the character referred to having an improved feedback circuit providing a relatively high impedance in connection with the amplifier output circuit and a relatively low impedance in connection with the amplifier input circuit.

It is also an object of the present invention to provide an inverse feedback amplifier having a separate feedback circuit provided with an amplifier tube for coupling the amplifier output circuit to the amplifier input circuit through a common cathode connection between said coupling tube and the amplifier input stage.

It is an object of the present invention to provide a coupling tube in the feedback circuit as above referred to, which in itself operates as a feedback amplifier to reduce distortion in the feedback loop.

It is a still further object of the present invention to provide an inverse feedback amplifier having a coupling tube in the external portion of the feedback loop between the amplifier output circuit and the amplifier input circuit, the load impedance of which coupling tube is provided in the cathode circuit thereof in common with the cathode circuit of an input stage of the amplifier, said cathode impedance forming a relatively low impedance in the input circuit of the amplifier and said coupling tube providing a high impedance input connection with the output circuit of the amplifier, thereby to permit a high impedance output circuit in the amplifier without appreciable load as a result of deriving feedback energy therefrom.

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

In the drawing,

Figure 1 is a schematic circuit diagram of an inverse feedback amplifier embodying the invention;

Figure 2 is a similar schematic circuit diagram of an inverse feedback amplifier, also embodying the invention, and including a modification of the circuit of Fig. 1; and

Figure 3 is a schematic circuit diagram showing a further modification of the invention in

connection with the first stage of the amplifier shown in Fig. 2.

Referring to Fig. 1, an audio frequency inverse feedback amplifier is shown, by way of example, comprising a first stage amplifier tube 5 of the pentode type having a single input circuit 6 coupled to a signal input grid 7 through a suitable coupling capacitor 8 and grid resistor 9, the latter being provided with a return circuit through ground 10—11 to the cathode 12 through a resistor 13 in the cathode circuit.

The output anode circuit 14 of the first stage 5 is coupled through suitable impedance coupling means 15 with a second stage amplifier tube 16 having a high impedance output circuit 17 comprising a coupling resistor 18 of relatively high impedance adapted to supply amplified signal voltage to a succeeding amplifier stage, not shown, with a relatively high gain.

The resistor or impedance 13 included in the cathode circuit of the first stage amplifier tube 5 provides biasing potential for the grid 7 and is of relatively low impedance. Since this impedance is in series with the input circuit between the grid and the cathode, it is possible to supply an inverse feedback voltage therethrough which is in series with and opposed to the input signal voltage. The input circuit of the amplifier operates without substantial load and permits a high degree of gain both for input signals and for feedback potentials.

In order to couple the high impedance output circuit 17—18 to the low impedance element 13 in the input circuit of the amplifier, a coupling tube 20 is interposed between said output circuit and said input circuit, which may be of any suitable type having a cathode 21, a signal input grid 22 and an output anode 23.

The input circuit of the tube 20 includes an input lead 24 connected with a contact 25 on a high impedance potentiometer 26, one terminal 27 of which is connected through a source of biasing potential 28 to ground 29, while the opposite high potential terminal 30 is coupled through a suitable coupling capacitor 31 with the high potential side 17 of the amplifier output circuit.

The cathode 21 of the coupling tube 20 is connected through a lead 33 with the cathode terminal 34 of the cathode resistor 13 so that the cathode circuit of the coupling tube and of the first stage amplifier tube includes the common coupling impedance 13. Thus, the grid circuit of the tube 20 may be traced from the grid 22 through the lead 24 to the potentiometer contact

25, thence through the potentiometer impedance 26 and the biasing potential source 28 to ground 29—11 and back to the cathode 21 through the resistor or impedance 13 and the lead 33.

The anode circuit of the coupling tube 20 includes a source of anode potential represented by supply terminals 36 across which is connected a by-pass capacitor 37 providing an anode circuit to ground 38 of substantially zero impedance. The anode circuit return connection includes the ground 11 and the cathode 21 through the impedance device 13.

The circuit arrangement for the feedback coupling tube is such that the high impedance grid circuit thereof is coupled to the amplifier output circuit 17, thereby providing no appreciable load on the output circuit since the potentiometer and input circuit impedance is of the order of or higher than the output circuit impedance, and the potentiometer connection permits any desired portion of the output voltage to be applied to the grid 22 for inverse feedback in the ratio E_2/E_1 .

Since the anode current of both tubes 20 and 5 flows through the common cathode resistor or impedance 13 and as this resistor is preferably of a higher value than ordinarily provided for self bias, the cathode 21 of the tube 20 is maintained at a slightly more positive potential than the grid 22 by balancing the potential drop in the resistors 13 against the initial biasing potential provided by the source 28. A similar source of biasing potential is provided, as indicated at 32, in circuit with the grid 7 for the same purpose, so that both grids 7 and 22 are negatively biased in the absence of signals.

The operation of the circuit is as follows: Amplified signals are taken from the high impedance output circuit 17 through the coupling capacitor 31, which is of relatively low impedance at signal frequencies, across the potentiometer device 26. A portion E_1 of the output potential E_2 , is applied to the grid 22 of the coupling tube 20, which has its load impedance 13 in the cathode circuit in common with the cathode circuit of the first stage amplifier 5. Thus, an inverse feedback voltage across the impedance 13 is applied between the cathode and grid of the first stage amplifier tube 5.

Assuming a positive half cycle of signal voltage to be impressed upon the grid 7 of the tube 5, a negative half cycle of signal voltage corresponding thereto will be applied to the grid of the tube 16 and the corresponding positive half cycle of signal voltage will be derived from the output circuit 17 and applied to the grid 22 of the coupling tube 20. This causes the cathodes 21 and 12 to become more positive and effectively reduces the net signal voltage between the grid 7 and cathode 12 of the first stage amplifier. In other words, as the grid 7 of the input stage increases in voltage in a certain direction, the cathode likewise increases in voltage in the same direction and in a predetermined ratio, with the result that the voltage between grid and cathode is a predetermined fraction of the input signal voltage, that is, less than unity gain. The value of the inverse feedback potential applied to the input stage across the resistor 13 is determined by adjustment of the potentiometer device 25—26.

The load resistor 13 of the tube 20 is connected between cathode and ground so that the voltage developed across it is fed back to its own grid circuit. Thus the tube 20, with its load impedance, constitutes a single-stage, feed-back

amplifier having a gain of substantially unity and substantially zero harmonic distortion, and is located in the external circuit of the feedback loop for the purpose of impedance changing, and coupling the input and output circuits of the amplifier without appreciably loading said circuits, while the normal effect of feedback in reducing distortion is not modified or changed. The plate current of the tube 20 is maintained sufficiently high to provide the necessary variation of the cathode voltage on the tube 5 in the presence of the plate current of the latter tube.

The initial bias for the grid of the coupling tube 20 is preferably such that it operates in the absence of signals, at substantially the mid-point of the straight portion of its grid-bias, anode-current characteristic.

The common cathode connection for both the inverse feedback coupling tube and the first-stage amplifier tube may be provided as shown in Fig. 2 by a first-stage amplifier tube 45 having a signal input grid 46 and a signal output anode 47 associated with a common cathode 48 for the coupling tube grid 49 and coupling tube anode 50 in the same envelope.

In the circuit shown, the signal input grid 46 is coupled to a signal input circuit 51, and the common cathode connection includes a common cathode coupling resistor 52 as in the preceding example, with feedback from a potentiometer resistor 53 across the amplifier output circuit, through feedback circuit 54 to the grid 49 of the coupling tube, for the same purpose as in the circuit of Fig. 1. Means for utilizing the output signal from the output circuit 55 of the second stage amplifier tube 56 is indicated at 51.

Positive biasing potential for overcoming the high negative bias of the resistor 52 is provided by a separate source such as a bleeder resistor 58 having a ground connection 59 and a tap connection 60 to which the circuit 54 is connected through the potentiometer 53. A similar tap connection 61 is provided for the input grid circuit of the first-stage amplifier, this connection being provided with a suitable by-pass capacitor 62.

Referring to Fig. 3, a circuit is shown wherein the feedback potential is applied to an inner control grid 64 of a mixer tube 65 having an outer control grid 66 which operates as a signal grid. A common cathode for both grids is indicated at 67 and the grids 68 are screen grids for the signal grid 66. As in the preceding circuits, the common cathode connection is provided with a common impedance element 69 across which both signal and feed back potentials appear, since it is in the common cathode circuit for both of the control grids 66 and 64 and in circuit with the cathode for the anode current from the output circuit 71. The amplifier stage is otherwise coupled to the succeeding stages and to the feedback connection in the same manner as for the circuits in Figs. 1 and 2.

The signal input circuit for the grid 66 is indicated at 70. Biasing potential for the grids 66 and 64 is obtained from the source 72 through the leads 73 and 74, respectively. The lead 75 is the external circuit connection from the feedback potential source (not shown) which may be provided in any suitable manner as in Fig. 1 and with an odd number of stages to provide a high impedance across the output circuit of the amplifier as in the preceding circuits of Figs. 1 and 2.

I claim as my invention:

1. In a multi-stage amplifier, the combination of a signal input tube provided with a cathode, a low impedance coupling resistor in circuit with said cathode, an output tube having a high impedance output circuit, a potentiometer device in said output circuit providing a signal output connection, an inverse feedback coupling tube having a control grid connected with said signal output connection and a cathode connected with the first named cathode whereby said coupling resistor is common to said cathodes as a circuit element, means for applying anode current to said coupling tube through said coupling resistor, and an input circuit for said signal input tube having said coupling resistor included serially therein.

2. In an inverse feedback amplifier, the combination of means providing a plurality of amplifier stages including a first stage amplifier tube having a cathode, an input grid, a signal input circuit connected between said cathode and grid, an output amplifier stage having a high impedance output circuit, means for coupling said high impedance output circuit to said first stage amplifier tube including a coupling tube having a control grid coupled to said output circuit and a cathode connected with said first named cathode, a common low impedance coupling element in circuit with said cathodes and serially in said input circuit, and means for applying anode current to said coupling tube through said coupling element.

3. In an inverse feedback amplifier having an input circuit and an output circuit, means providing an inverse feedback loop comprising a plurality of amplifier stages between said input and output circuits, and an external feedback circuit between said output circuit and said input circuit, said last named circuit including a degenerative amplifier stage having a relatively high impedance in shunt to the output circuit and a relatively low impedance in series with the input circuit.

4. An inverse feedback amplifier including in combination, a first stage amplifier tube having a control grid, a cathode and an output anode, means providing a signal input circuit between said grid and cathode, an inverse feedback circuit including a coupling tube having a cathode connected to said first named cathode, a load resistor for said coupling tube providing a common impedance element in circuit with said cathodes, and serially in said input circuit, said resistor being of relatively low impedance, a signal input grid for said coupling tube, means providing a high impedance input circuit between said last named grid and said cathodes through said load resistor, an output circuit for said amplifier, and means for coupling said high impedance input circuit thereto.

5. An inverse feedback amplifier comprising, in combination, a first stage amplifier tube having a signal input grid, a cathode and a signal input circuit connected with said grid, means providing a high impedance output circuit for

said amplifier, means for deriving a portion of the output voltage therefrom, a second amplifier tube having a control grid connected with said last named means and having a cathode and an anode, means providing operating potential for said anode, an output load resistor serially connected between said last named means and said last named cathode and degeneratively in circuit with said control grid through said output voltage deriving means, and means providing a circuit connection between said cathodes and a second connection between said first named cathode and said input circuit through said load resistor.

6. An inverse feedback amplifier comprising, in combination, a first stage amplifier tube having a signal input grid, a cathode and a signal input circuit connected with said grid, means providing a high impedance output circuit for said amplifier, means providing a high impedance in said output circuit for deriving a portion of the output voltage therefrom, a second amplifier tube having a control grid connected with said last named means and having a cathode and an anode, means providing operating potential for said anode, an output load resistor serially connected between said last named means and said last named cathode and degeneratively in circuit with said control grid through said output voltage deriving means, and means providing a circuit connection between said cathodes and a second connection between said first named cathode and said input circuit through said load resistor, whereby inverse feedback potentials of predetermined amplitude are derived from said high impedance output circuit and applied to said input circuit across said output load resistor, said resistor being of relatively low impedance with respect to said input circuit impedance.

7. A circuit arrangement comprising a chain of electron discharge tube stages, a feedback circuit connected between an output circuit of one of said stages and an input circuit of a preceding one of said stages, an electron discharge tube in said feedback circuit, and a circuit connection to ground from the cathodes of the tubes in said preceding stage and in said feedback circuit respectively, said circuit connection including a cathode impedance common to the two cathodes.

8. In combination, a signal supply circuit, a plurality of cascaded amplifier stages coupled to said circuit, the first of said stages having a discharge tube whose cathode is connected to ground through an impedance, and a successive one of said stages having an output circuit and a feedback circuit connected thereto, said feedback circuit including a discharge tube having a cathode, an anode, and at least one grid, the grid being controlled by potentials in said feedback circuit, and the cathode thereof having an impedance path to ground which is in part common to at least a portion of the cathode impedance of the tube in said first stage.

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