

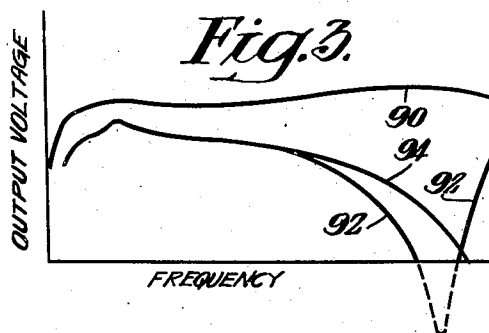
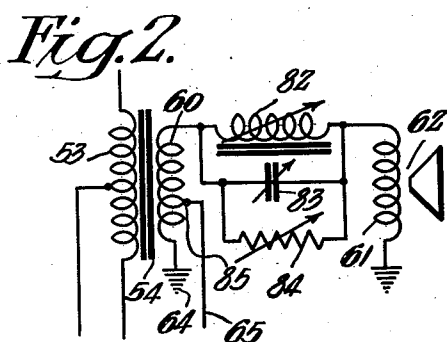
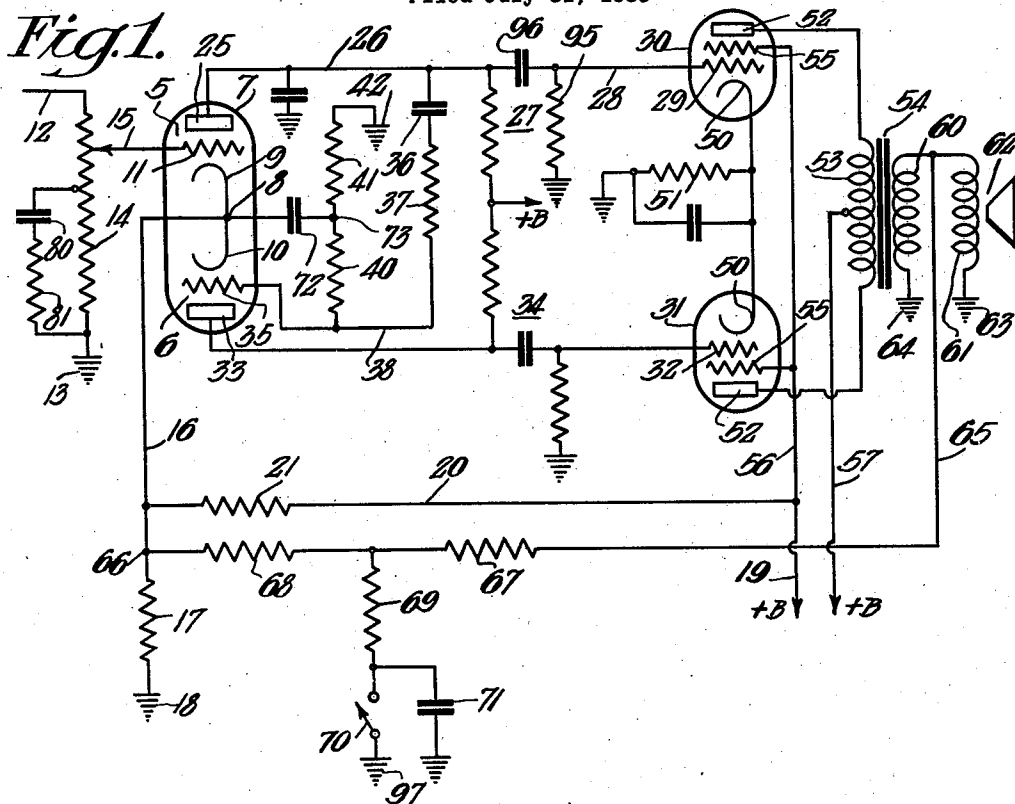
May 5, 1942.

J. M. RIDDLE, JR

2,281,618

INVERSE FEEDBACK AMPLIFIER

Filed July 31, 1939



Inventor
James M. Riddle Jr.

J. J. Huff
Attorney

UNITED STATES PATENT OFFICE

2,281,618

INVERSE FEEDBACK AMPLIFIER

James M. Riddle, Jr., West Collingswood, N. J.,
 assignor to Radio Corporation of America, a
 corporation of Delaware

Application July 31, 1939, Serial No. 287,612

3 Claims. (Cl. 179—171)

The present invention relates to inverse feedback amplifiers. More particularly, it relates to impedance or resistance coupled amplifiers with inverse feedback, and has for its object to provide a high quality, low distortion feedback amplifier of that type having a minimum number of circuit components.

It is also an object of the present invention to provide a resistance coupled amplifier comprising a balanced push-pull output stage with driver and phase inverter stages therefor combined in one tube or having a common cathode connection and with a filter network for the inverter grid circuit, permitting the use of said common cathode connection without feedback on the phase inverter stage.

It is a further object of the present invention to provide an improved inverse feedback amplifier including a phase inverter and a driver stage in which the two stages may include a single tube having a common cathode connection for both stages to which the feedback may be applied for the driver stage and to the exclusion of the inverter stage.

It is a still further object of the present invention to provide an improved phase inverter network for an impedance coupled amplifier adapted for inverse feedback and improved means for controlling the frequency response of the amplifier outside of the feedback loop.

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 audio frequency amplifier embodying the invention;

Figure 2 is a similar schematic circuit diagram of a portion of the circuit of Fig. 1 showing a modification; and

Figure 3 is a graph showing curves illustrating the operation of the circuit of Fig. 2.

Referring to Fig. 1, the audio frequency amplifier comprises first stage amplifier elements 5 and inverter amplifier elements 6 contained in a common tube envelope 7 with a common cathode connection 8 for the cathodes 9 and 10. While the preferred arrangement providing a common tube for both the amplifier and inverter is shown, separate tubes with a common cathode connection may be used.

Each of the amplifier tube elements 5 and 6, hereinafter referred to as tubes, within the en-

velope 7, may be of any suitable type and in the present example are shown as triodes, the tube 5 having a signal input or control grid 11 connected with an audio frequency input circuit 12—13 through a volume control potentiometer 14—15 in the grid circuit of the tube. Biasing potential is applied between the cathode 9 and the grid 11 through a common cathode connection 16, a common cathode bias resistor 17, a ground or chassis connection 18 and the input potentiometer 13—14—15. The cathode resistor 17 is maintained at a low resistance value to reduce the impedance between the cathode and ground. A desired bias potential is established therein by bleeder current derived from a positive supply lead 19 through a connection 20 and a series bleeder resistor 21, the negative B supply being the chassis or ground.

With a tube 7 of the RCA 6Z7-G type, the bleeder resistor 21 may be of the order of 50,000 ohms and the resistor 17 may be of the order of 500 ohms in an amplifier of the type shown.

The output anode of the first stage amplifier is indicated at 25 and is coupled through an output circuit 26 and suitable impedance coupling means 27 with the grid circuit 28 and control grid 29 of one of a pair of push pull output tubes 30 and 31. The input or control grid 32 of the tube 31 is similarly coupled to the output anode 33 of the inverter tube 6 through impedance or resistance coupling means indicated at 34. Since the impedance coupling means referred to is of the anode resistor, grid resistor and coupling capacitor type well known in the art, further description of this type of coupling is believed to be unnecessary.

As is well known, the phase inverter tube 6 is employed to derive from the single channel input represented by the tube 5, a push pull or balanced output signal for the tubes 30 and 31, and for this purpose the control grid 35 of the inverter tube 6 is coupled to the output circuit 26 of the first stage 5 through a suitable coupling capacitor indicated at 36 and a series resistor 37 connected to the input grid lead 38. Alternatively, resistor 37 may be connected directly to line 28 thereby utilizing capacitor 36 as a coupling capacitor for both grid 29 and grid 35, thereby eliminating capacitor 36.

The resistor 37 is part of a filter network comprising a second resistor having series sections 40 and 41 connected between the grid circuit 38 and chassis ground 42. Grid bias potential from the resistor 17 is also supplied to the grid 35

through this connection so that both grids 35 and 11 are substantially equally biased.

The grid 35 receives an amplifier signal from the output circuit 26 of the first stage substantially 180 degrees out of phase with the signal applied to the grid 11 and in order that the signal potentials on both grids may be of the same amplitude, the grid network 37, 40, 41 is designed with proper values of resistance to reduce the amplifier signal at the lead 38 and the inverter stage grid to the desired value. In the present example the capacitor 36 may be considered to be of the order of .0025 mfd. and the resistors 37, 40 and 41 may have values of the order of 680,000 ohms, 18,000 ohms and 1.0 megohm, respectively, the ratio being such that

$$\frac{R_{41} + R_{40}}{R_{41} + R_{40} + R_{37}} = \frac{1}{\text{Gain of tube 5}}$$

The push-pull output stage comprising the tubes 30 and 31 may be of any suitable type, and in the present example is of the push-pull, beam power type, the tubes 30 and 31 each having a cathode 50 connected to chassis or ground through a common self-bias resistor 51 and having output anodes 52 connected in balanced relation to each other through the primary 53 of an output transformer 54. The screen grids 55 of the tubes are connected to the positive supply lead 19 through a lead 56 while the output anodes receive a higher positive potential through a supply lead indicated at 57.

The secondary of the output transformer is indicated at 60 and is connected to the voice coil leads of a loud-speaker device 62 having a return circuit comprising a chassis ground connection 63 for one side of the voice coil and a chassis ground connection 64 for one side of the secondary 60.

Inverse feedback energy from the secondary 60 for correcting amplifier distortion is applied across the common resistor 17 by reason of the ground connection 64 for one side of the secondary to the ground connection 18 for the resistor 17. A feedback lead 55 connected with the opposite or ungrounded side of the secondary 60, and with the cathode end 66 of the resistor 17 through a pair of series connected feedback potential drop producing resistors 67 and 68 completes the feedback circuit to the input of the driver stage. The resistors may be eliminated if the lead 55 is tapped to the secondary 60 as indicated in Fig. 2 which will hereinafter be referred to.

Between the resistors 67 and 68 is connected a shunt bypass circuit to ground comprising a series controlling resistor 69 and a switch 70 shunted by a bypass capacitor 71 which shunts out high frequency disturbances in the switch circuit from the receiver circuits. In the open position the switch permits a predetermined amount of feedback to flow from the output circuit to the common cathode resistor 17 thereby raising and lowering the common cathodes 9 and 10 above ground in accordance with variations in feedback. When the switch is closed the feedback potential is reduced to a greater degree thereby increasing the gain of the amplifier, and in the present example is arranged to provide substantially 3.0 DB increase in gain.

For automobile receivers, in particular, the switch 70 is operated when driving at high speeds to increase the output of the receiver to overcome the windage and other noises incident to the higher speed operation. In the present ex-

ample, the resistor 68 provides a major portion of the feedback potential drop and may be of the order of 2200 ohms, while the resistors 67 and 69 are of the order of 80 ohms each with the bypass capacitor 71 of .05 mfd., as a further aid in maintaining audio frequency disturbance voltages at a minimum. The resistors 67 and 69 are made substantially $\frac{1}{30}$ of the value of the resistor 68 so that the disturbance effect across the resistor 17 by reason of undesired pickup in the switch circuit may be minimized. In an automobile receiver also the tubes 30 and 31 may be of the RCA 6V6 type.

It is obvious that serious distortion will be introduced into an amplifier having a phase inverter with a common cathode connection if inverse feedback potentials are applied to the phase inverter stage. However, it has been found that this type of amplifier may be operated such that substantially no inverse feedback voltage reaches the inverter stage grid 35 by further arranging the feedback and inverter input grid networks in such a manner that the inverse feedback voltage is filtered out of the inverter grid circuit. To this end the value of resistance for the resistor 41 is chosen to operate with a capacitor 72 as a filter in the coupling network 36—37—40—41, the capacitor being connected between the common cathode connection 8—16 and a tap 73 on the resistor 40—41 between the input grid circuit 38 of the inverter tube 6 and ground 42. In the present example, the tap connection is located between sections 40 and 41, such that the said resistor sections and the capacitor 72 provide a grid filter substantially tying the grid 35 and the grid circuit 38 to the common cathode connection 8—16 for feedback potentials while at the same time the control grid 35 of the inverter stage 6 receives, at the proper amplitude, the inverter voltage derived from the output circuit 36, that is, substantially 180 degrees out of phase with the signal voltage on the grid 11 and at substantially the same signal amplitude by reason of the further inclusion in the filter circuit of a relatively low resistance at 40 between the grid circuit 38 and the cathode filter capacitor section 73.

The capacitor 72 is of the order of .25 mfd. while the resistor 40 is of the order of 18,000 ohms resistance as compared with the relatively higher resistances at 41 and 37 of 1.0 megohm and 680,000 ohms, respectively. The signal control grid 35 of the inverter stage 6 is raised and lowered above ground by the inverse feedback voltage substantially with the common cathode connection 8—16 and the cathode 10, whereby the inverse feedback voltage is prevented from actuating the grid 35 and introducing distortion. The attenuation of feedback voltage with respect to grid 35 is in the order of 40 DB at low frequencies. The attenuation may be expressed approximately as

$$\frac{R_{41}}{\sqrt{\left(\frac{1}{WC_{72}}\right)^2 + (R_{41})^2}}$$

By thus providing a relatively high resistance inverter grid circuit between the first stage output circuit 26 and ground, a relatively low resistance section thereof may be selected to derive a required inverter voltage equal to the signal input voltage while at the same time the inverter input grid is substantially connected with the inverter cathode with respect to the inverse feedback voltage. This is provided by a minimum num-

ber of simple circuit components of low cost, and a simple filter and bleeder network having only two connections thereon, one for the inverter grid and one for the filter capacitor 72 to cathode.

It will be noted that the volume control device 14-15 for the amplifier is provided with a tone control network comprising a capacitor 80 and a series resistor 81 shunted across a portion of the volume control resistor 14. Thus the audio amplifier, a portion of which is included in the feedback loop, may be provided with tone control means which is connected outside the feedback loop to properly control the tone characteristic of the amplifier without introducing distortion.

Likewise and preferably a tone control circuit may be included outside the portion of the amplifier which includes the feedback loop, for example as shown in Figure 2, between the output transformer 54 and the loudspeaker device 62 in a series connection between the secondary 60 and the voice coil 61. This comprises a suitable combination of inductance, indicated at 82, capacity, indicated by the capacitor 83, and resistance, indicated by the resistor 84. The feedback voltage is taken as in Fig. 1 through the lead 65 and the ground connection 64 on the amplifier side of the loudspeaker circuit so that the correcting network 83-83-84 is connected between the feedback connection 65 and the voice coil 61.

Since the inverse feedback connection tends to provide the amplifier with a substantially flat frequency response characteristic, it is obvious that this may be modified without introducing distortion in the amplifier by the network referred to, and thus attenuate or accentuate any portion of the audio frequency signal range. For example, in the system shown, by properly adjusting the circuit constants, the high frequency signals may be divided between the voice coil 61 and the inductance 82 so that the said high frequency signals are attenuated as may be desired in the operation of said receiving and amplifying systems.

On the other hand, the network may be adjusted to accentuate or attenuate any other frequency range as desired. However, it should be understood that the direct current resistance of the inductance 82 is preferably low compared with that of the voice coil 61, and that the maximum value of resistance 84 is preferably several times that of the impedance of inductance 82.

The curves 90, 92 and 94 in Fig. 3 indicate, respectively, the normal output frequency response of the amplifier, the frequency response as modified by tuning the inductance 82 and the capacitor 83 to a rejection frequency of substantially 5,000 cycles, and the effect of the inductance 82 alone in the circuit. It is obvious that the response characteristic of the amplifier at the loudspeaker circuit may be modified in any suitable manner by adjustment of the circuit elements shown in Fig. 2, and that the tone control means in the output circuit may be combined with tone control means preceding the portion of the amplifier including the feedback loop, to provide any other desired output characteristic.

I claim as my invention:

1. In an audio frequency amplifier, the combination of an output transformer having a sec-

ondary winding provided with a chassis ground connection and a feedback connection lead, a pair of amplifier tubes having a common cathode connection to chassis including a biasing resistor connected at the cathode end with said feedback lead, means in said feedback lead for controlling an inverse feedback voltage therethrough, means for providing a bleeder current through said cathode resistor whereby for a predetermined bias potential the resistance to chassis of said resistor may be relatively low, means providing a circuit between said amplifier tubes for effecting phase inversion of an applied signal potential, and means including a filter in said last named connection for preventing inverse feedback potential from said common cathode connection from initially reaching said inverter stage, thereby to prevent distortion of an applied signal through said amplifier.

2. In an audio frequency amplifier, the combination with a balanced output amplifier stage, comprising a pair of amplifier tubes having a balanced input circuit and a balanced output circuit, of a combined signal amplifier and inverter tube each having an output anode resistance coupled to said balanced input circuit and a signal input grid, means providing a common cathode connection for said amplifier and inverter stages including a common bias potential supply resistor for said grids, means connected with said output circuit for applying a controlled inverse feedback potential across said last-named resistor, whereby the common cathode connection for said stages is varied above ground in response to variations in inverse feedback potential, and means providing an inverter voltage connection between the output circuit of the amplifier stage and the control grid of the inverter stage, said connection including a filter network having a resistor and a capacitor in series between said inverter control grid and cathode connection of relatively low resistance with respect to the resistance of said inverter voltage connection, whereby for inverse feedback voltages said inverter cathode and control grid operate at substantially the same potential.

3. In a resistance coupled amplifier, comprising a driver stage, a phase inverter stage having an input circuit, a pair of balanced amplifier tubes providing a second stage, impedance coupling means between said last named stage and said driver and phase inverter stages, means providing a common cathode connection including a low resistance bias resistor for said phase inverter and driver stages, means for applying an inverse feedback potential from said second stage to the cathode end of said bias resistor, and means for preventing the application of said inverse feedback potential to the inverter stage input circuit comprising a filter network providing potential drop producing coupling between said driver stage and said inverter stage for signal potentials, and an alternating current low impedance connection between the inverter stage input circuit and said common cathode connection for causing said input circuit to operate at cathode potential with respect to inverse feedback potentials.

JAMES M. RIDDLE, Jr.