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BALANCED AMPLIFIER

Filed March 30, 1945

Fig. 1.

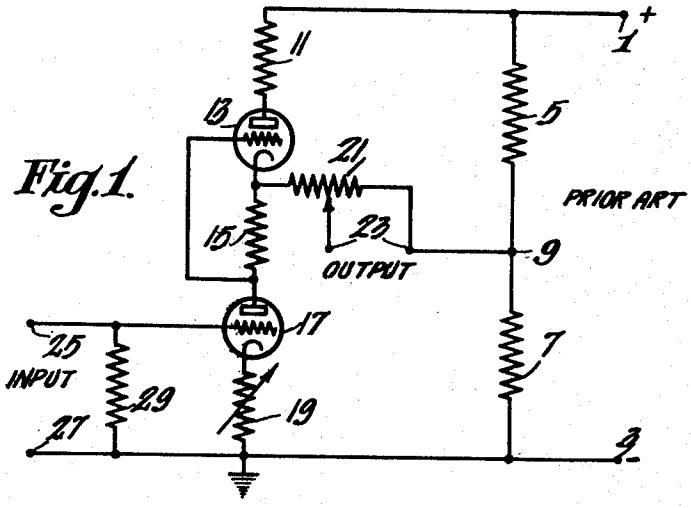


Fig. 2.

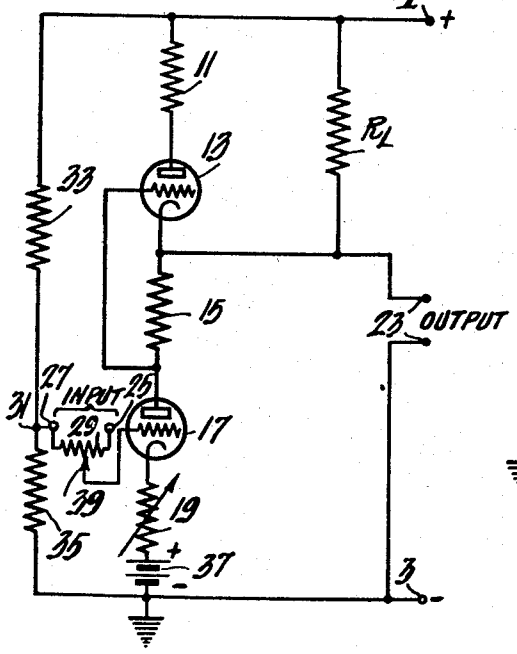
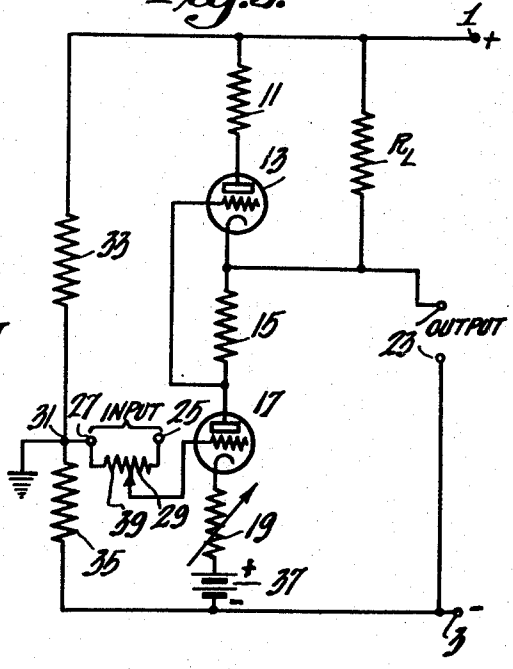


Fig. 3.



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BALANCED AMPLIFIER

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6 Claims. (Cl. 179—171)

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This invention relates generally to direct and alternating current amplifiers and more particularly to balanced amplifiers which are compensated for variations in power supply voltage.

Direct current amplifiers usually are responsive to changes in power supply voltage. These changes alter the gain of the amplifier and disturb the zero setting. In both A.-C. and D.-C. amplifiers requiring a high degree of gain stability, it is customary to provide a regulated power supply source. Such regulated power supply sources are complicated, expensive and often are incapable of providing the desired gain stability.

The instant invention is an improvement upon the device disclosed and claimed in U. S. Patent 2,310,342, granted to Maurice Artzt on February 9, 1943, and assigned to the same assignee as the instant application. The invention herein will be explained first by reference to the device described in said patent and then by reference to various modifications and improvements thereof to provide the desired gain stability.

Among the objects of the invention is to provide stabilized means for amplifying direct currents. Another object of the invention is to provide A.-C. and D.-C. amplifying means in which the D.-C. level is substantially independent of variations in power source voltage. An additional object is to provide stabilized amplifying means in which the gain may be varied without disturbing the D.-C. zero input setting. A further object is to provide current amplifying means including self-regulation of energizing power source voltages. An additional object of the invention is to provide an improved gain-stabilized amplifier in which the output voltages are stabilized with respect to one terminal of the energizing voltage source. A further object is to provide an improved current amplifier having a feedback circuit for making the amplifier signal output substantially independent of energizing voltage fluctuations.

The invention will be described by reference to the accompanying drawing of which Figure 1 is a schematic circuit diagram of a prior art amplifying system of which the instant invention is an improvement, Figure 2 is a schematic circuit diagram of a first embodiment of the invention and Figure 3 is a schematic circuit diagram of a second embodiment of the invention. Similar reference characters are applied to similar elements throughout the drawing.

Referring to Figure 1, a power source, not shown, is connected to power terminals 1, 3, which are also connected to the end terminals

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of a pair of serially-connected resistors 5, 7, having equal resistance values and having a common intermediate terminal 9. An anode resistor 11, the anode-cathode circuit of an output triode 13, an intermediate anode resistor 15, the anode-cathode circuit of an input triode 17, and a cathode resistor 19 are serially-connected, in the order named, between the power source terminals 1 and 3. If desired, the negative power source terminal 3 may be grounded. An output impedance 21 is connected between the cathode of the output triode 13 and the intermediate terminal 9 on the voltage divider 5, 7. Output signals are derived from output terminals 23, coupled to the end terminal and an adjustable tap on the output impedance 21. The control electrode of the output triode 13 is connected to the anode of the input triode 17, whereby the tubes are coupled in cascade. Input signals are applied to the input terminals 25, 27 which are connected, respectively, to the grid of the input triode 17 and to ground. A grid resistor 29 is connected in parallel with the input terminals 25, 27.

The operation of the circuit is as follows: Whatever the voltage of the power source may be, it is divided equally across the voltage dividing resistors 5 and 7. Preferably the voltage of the power source is selected to be equal to twice the rated voltage of either tube. Resistors 15, 19 are normally equal, and of a value which permits normal anode current to flow through the tubes for class A amplifier operation. It follows that the current through the cathode resistor 19 will equal the current through the intermediate resistor 15 and will be of the proper value to bias the output amplifier tube 13 for correct class A operation. Furthermore, if the resistance of the anode resistor 11 is selected to be equal to the sum of the resistances 15 and 19, the anode current through the output tube 13 will equal that through the input tube 17. Therefore, the voltage drop through the input tube 17 and the resistors 15 and 19 will equal the voltage drop across the voltage dividing resistor 7. Also, the voltage drop through the output tube 13 and the anode resistor 11 will equal the voltage drop across the voltage dividing resistor 5. Since the currents through the output impedance 21 (in the absence of an input signal), are equal and opposite, there will be zero output voltage across said output impedance. Thus, the output voltage across the output impedance 21 will remain zero for all variations of the voltage of the power source.

If a signal, for example, of one volt positive, is

applied to the grid of the input amplifier tube 17, the anode current of the tube will increase, and this will increase the voltage drop in the resistors 15 and 19, and across the output impedance 21. The current in the cathode resistor 19 will be degenerative, and the final change in bias across the cathode resistor 19 may be one volt less a half volt, or a half volt positive. A similar voltage change across the intermediate resistor 15 will be in the opposite direction and will decrease the current flowing through the anode resistor 11 and through the ouput impedance 21. Since, in the presence of an input voltage, the anode current of input tube 17 increases the voltage drop across the output impedance 21, and the anode current of the output tube 13 decreases the voltage drop across said output impedance, it follows that a negative ouput voltage will be developed across the output impedance.

It the input signal to the input tube 17 had been assumed to be negative, the anode current of the tube would have decreased, and the anode current of the output tube 13 would have increased, thereby making the output voltage across the output impedance positive. By setting the value of the cathode resistor 19 to a value which makes the potential across the output impedance 21 a zero value with no input signal, the system will be balanced, the output voltage will be affected only by the input signal, and the gain will be constant over a relatively wide variation of supply voltage. The gain of the amplifier may be varied by means of the adjustable tap on the output impedance 21.

The device thus described substantially balances the output signal voltages with respect to the potential of the intermediate terminal 9 on the voltage divider 5, 7 and substantially compensates for variations in the power source over a substantially wide range.

The improved circuit employing the instant invention, illustrated in Figure 2, is essentially similar to the circuit of Figure 1, with the exception that resistors 5, 7 and 21 are omitted and the input signal applied to the input terminals 25, 27 is applied between the grid of the tube 17 and the common terminal 31 of a feedback network including resistors 33 and 35. The end terminals of the feedback network 33, 35 are connected to the positive terminal of the anode resistor 11 and to ground, respectively. Output signals are taken from terminals 23 connected to the cathode of the output tube 13 and the negative power supply terminal 3. If the values of the resistors 33, 35 are selected so that the ratio of the resistance of the resistor 35 to the sum of the resistances of the resistors 33 and 35 is equal substantially to the reciprocal of twice the amplifier gain, output signals will be stabilized with respect to the grounded negative terminal of the power supply. This condition obtains since feedback voltages from the positive terminal of the anode resistor 11 applied to the grid circuit of the input tube 17 are of the correct amplitude and phase to neutralize the effect of variations in anode voltage, so that the D.-C. output level remains substantially constant in the presence of energizing voltage variations.

A bias voltage, supplied by a battery 37 connected in series between the cathode resistor 19 and ground, maintains the cathode of the input tube 17 at a positive potential with respect to ground. This bias voltage should be selected to be substantially the same as the quiescent voltage on the grid of the tube resulting from the feedback circuit 33, 35. A resistor R_L may be connected between the positive terminal 1 of the power supply and the ungrounded output terminal if the output impedance is other than a relatively high value. Gain control may be provided by an adjustable tap 39 on the shunt resistor 29, which is connected across the input terminals 25, 27.

The circuit of Figure 3 is similar to the circuit of Figure 2 with the exception that the common terminal 31 of the feedback resistor network 33, 35 is grounded. Output signals are derived from the cathode of the output tube 13 and the negative terminal 3 of the power supply. The operation of the circuit of Figure 3 is substantially identical to that of the circuit of Figure 2 in that the output signals are stabilized with respect to the negative terminal 3 of the power source. In both circuits, output signals are compensated for energizing voltage variations, and the output is stabilized with respect to the reference level of the input signals.

Thus, the invention described comprises a self-stabilizing A.-C. or D.-C amplifier, wherein the D.-C. level is substantially independent of power source variations as a result of a novel balancing circuit. The balancing characteristics tend to neutralize hum or like disturbances in the power source, thus permitting cheaper and more efficient rectifier and filter systems than may customarily be employed as a power source for high fidelity amplifier systems. The novel feedback circuit also balances the amplifier output signals with respect to selected points of circuit reference potential.

I claim as my invention:

1. In a balanced amplifier including terminals for a source of unidirectional voltage, input and output electron discharge devices provided with cathode-anode circuits including three anode circuit resistors, said resistors and said anode-cathode circuits of said devices being connected in series across said source terminals and said discharge device being coupled in cascade, and output means connected between the cathode of said output device and the negative terminal of said voltage source, the improvement comprising a feedback circuit including impedance means having end terminals connected to said source terminals and an intermediate terminal, and signal supply means connected between said intermediate terminal and the input circuit of said input device.

2. In a balanced amplifier including connections for a source of unidirectional voltage, input and output electron discharge devices provided with cathode-anode circuits including three anode circuit resistors, one of said resistors being connected in series between one of said source connections and the anode of said output device, a second of said resistors being connected in series between the other of said source connections and the cathode of said input device, and the third of said resistors being connected in series between the anode of said input device and the cathode of said output device, said output device having its input circuit connected across said third resistor, and an output circuit connected between the cathode of said output device and said other source connection, the improvement comprising a feedback circuit having end terminals connected to said source connections and an intermediate terminal, and signal supply means connected between said intermediate terminal and the input circuit of said input device

for stabilizing the output of said amplifier to compensate for energizing voltage source variations.

3. In a balanced amplifier including connections for a source of unidirectional voltage, input and output electron discharge devices provided with cathode-anode circuits including three anode circuit resistors, one of said resistors being connected in series between one of said source connections and the anode of said output device, a second of said resistors being connected in series between the other of said source connections and the cathode of said input device, and the third of said resistors being connected in series between the anode of said input device and the cathode of said output device, said output device having its input circuit connected across said third resistor, and an output circuit connected between the cathode of said output device and said other source connection, the improvement comprising a feedback circuit including a pair of serially-connected resistors connected between said source connections, and signal supply means connected between the junction of said feedback resistors and the input circuit of said input device for stabilizing the output of said amplifier to compensate for energizing voltage source variations.

4. Apparatus as claimed in claim 3 characterized in that the ratio of the smaller of said feedback resistances to the sum of said serially-connected feedback resistances is substantially the reciprocal of twice the gain of said amplifier.

5. Apparatus as claimed in claim 3 wherein said junction of said serially-connected impedances is a point of reference potential.

6. Apparatus as claimed in claim 3 wherein said connection of said feedback circuit to said other source connection is a point of reference potential.

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