

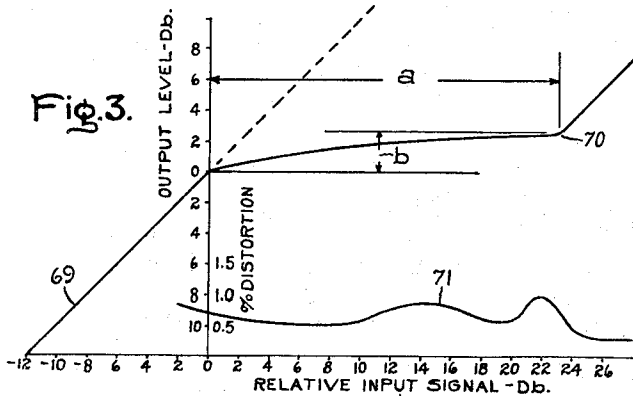
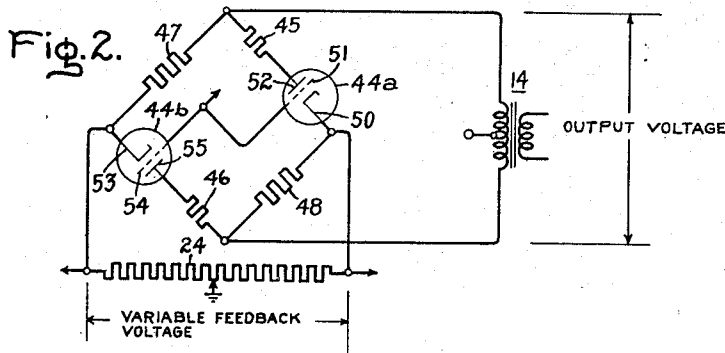
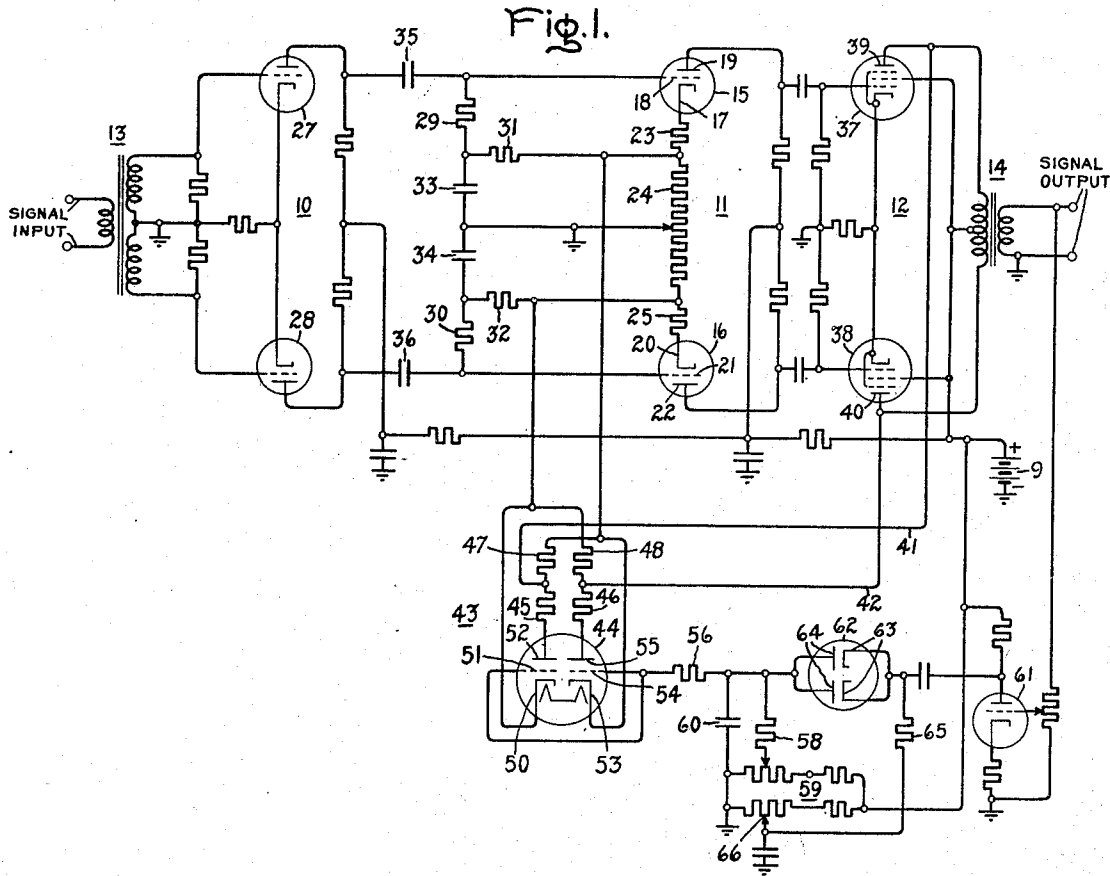
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AMPLIFIER

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2,369,066

AMPLIFIER

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10 Claims. (Cl. 179—171)

My invention relates to amplifiers and particularly to amplifiers provided with negative feedback circuits and controls for determining the amount of negative feedback to provide automatic level or gain control.

It is an object of my invention to provide an amplifier having negative feedback and an improved arrangement for controlling the amount of feedback to provide automatic gain control.

The features of my invention which I believe to be novel 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 accompanying drawing in which Fig. 1 is a diagrammatic representation of one form of amplifier embodying my invention; Fig. 2 is a diagram of the bridge circuit in the feedback path of the amplifier of Fig. 1; and Fig. 3 is a graph representing certain operating characteristics of the amplifier of Fig. 1.

Referring now to Fig. 1, the amplifier comprises three resistance coupled push-pull amplifier stages, 10, 11, and 12, which may, for example, be the speech input amplifier for a broadcasting station transmitting equipment. The signal to be amplified is supplied to an input transformer 13 and is impressed on the first amplifier stage 10 and is then amplified in turn by the stages 11 and 12 and supplied to an output transformer 14; the secondary of the transformer 14 may be connected to supply a transmitter or other utilization equipment in the usual manner. The device 15 includes a cathode 17, a grid or control electrode 18 and an anode 19. The device 16 includes a cathode 20, control electrode 21 and an anode 22. The cathodes 17 and 20 are connected by resistances 23, 24 and 25, the mid-portion of resistance 24 being connected to ground through an adjustable contact. The outputs of electron discharge devices 27 and 28 of the push-pull stage 10 are coupled to the grids 18 and 21, respectively, through capacitors 35 and 36 and resistors 29 and 30. Grid 18 is connected to cathode 17 through resistors 29, 31, and 23, while grid 21 is connected to cathode 20 through resistors 30, 32, and 25. A capacitor 33 acts to maintain the junction of resistors 29 and 31 at audio frequency ground potential, while a capacitor 34 acts likewise to maintain the junction of resistors 30 and 32 at audio frequency ground potential. Resistors 23 and 25 act as biasing resistors

for devices 15 and 16, respectively. A feedback path is provided between the output of the amplifier stage 12 and the cathode circuits of the devices 15 and 16 in order to provide negative feedback and limit the gain of the amplifier.

The stage 12 comprises electron discharge devices 37 and 38 having anodes 39 and 40 connected to opposite ends of the primary of transformer 14, the direct current anode voltage being supplied to a center tap of the primary from a suitable source such as a battery 9. The feedback circuit comprises leads 41 and 42 connected respectively to the anodes 39 and 40 and connected across one diagonal of a bridge circuit 43, the other diagonal of which is connected across the resistance 24. Since the output of the stage 12 is coupled across resistors in the cathode leads of the stage 11, audio frequency current flowing through the feedback path produces a degenerative voltage in the cathode circuit of stage 11 and reduces the gain of the amplifier. The bridge 43 comprises an electron discharge device 44 of the double triode type the two halves of which are connected in series through resistors 45 and 46 to form two opposite arms of the bridge, the other two arms of which are formed by resistors 47 and 48. The arrangement of the bridge is more clearly indicated in Fig. 2 in which the two halves or electron discharge devices of the tube 44 connected in series with the resistances 45 and 46 are indicated as separate tubes 44a and 44b, respectively. The device 44a comprises a cathode 50, a grid or control electrode 51 and an anode 52 and the device 44b comprises a cathode 53, a grid or control electrode 54 and an anode 55. The grids 51 and 54 are connected together and through resistances 56 and 58 and a parallel resistance network 59 to the direct current source 9. The resistance 58 is adjustable with respect to the network 59 so that the bias on the grids 51 and 54 may be varied. This bias is adjusted so that the bridge is balanced provided that the output signal does not exceed a predetermined maximum intensity; in other words, when the output signal does not exceed a certain predetermined intensity, no degenerative voltage is fed back from stage 12 to stage 11. The balance of the bridge circuit 43 is arranged to be controlled in accordance with the intensity of the signal at the output of the amplifier. This is accomplished by varying the bias of the control grids 51 and 54 in proportion to output signal intensities above a predetermined value. The bias in the presence of an increasing output sig-

nal intensity becomes increasingly negative. An amplifier including an electron discharge device 61 is connected across the output of the transformer 14 and amplifies the output signal and impresses it upon a rectifier including an electron discharge device or diode 62 having cathodes 63 and anodes 64. The load circuit of the diode 62 comprises a resistance 65, the network 59 from an adjustable contact 66 to the resistance 58, and the resistance 58 bypassed by a condenser 60. The diode 62 is biased by adjustment of the contact 66 so that the diode will not pass current until a signal of at least a predetermined intensity is supplied from the device 61; however, as soon as this value of signal is exceeded current passes through the device 62 and the bias on the grids 51 and 54 is changed; this unbalances the bridge, the degree of unbalance of the bridge depending upon the intensity of the signal impressed across the rectifier 62. Since the audio frequency current flowing through the bridge produces a voltage in the resistor 24 in phase with the voltage on the grid of the respective one of the devices 15 and 16, the amount of degeneration is proportional to the degree of unbalance of the bridge which in turn is proportional to the intensity of the output signal. The operating characteristics of the amplifier are indicated in Fig. 3, the curve 69 of which shows relative input signal plotted against the output level in decibels. The zero value of relative input signal has been taken as the value below which the bridge 43 is balanced. The output signal thus varies directly in proportion to the input signal below this value, however, as soon as the control circuit operates to unbalance the bridge, the output level is decreased and is maintained substantially constant until it reaches a value indicated at the bend 70 on the curve 69, at this point the devices 44a and 44b have reached cutoff bias and are effectively open circuited. After this point has been reached the amplifier acts as an ordinary degenerative amplifier with a constant value of negative feedback equal to that at the point 70. Beyond the point 70 the output signal again varies directly in proportion to the input signal as indicated in Fig. 3 by the straight line parallel to that portion of the curve below the zero decibel relative input signal line. It will be noted that the portions of the curve indicated at a and lying between zero relative input signal and the point 70 provides substantially constant output level, the total variation over the range of operation as indicated at b being less than three decibels. A curve 71 in Fig. 3 indicates the percentage distortion of the signal over the range of relative input signals. It will be noted from this curve that percentage distortion remains below one percent over the operating range a of the amplifier.

The resistors 45 and 46 employed in the opposite arms of the bridge 43 in series with the two halves of the device 44 have been found to render the bridge very stable and minimize signal distortion. Furthermore, the feedback loop includes only two resistance capacity coupled stages so that the phase shift around the loop can be 180° only at zero frequency and at infinite frequency and within the range of frequencies normally encountered the phase shift is much less than 180°. Consequently, the 180° phase shift necessary for oscillation is not attained and parasitic oscillations are prevented;

the circuit is unconditionally stable for all degrees of feedback.

This amplifier circuit has the advantage that ordinary triode tubes may be employed throughout and there is no need for especially matched tubes in the automatic gain control circuit. The circuit is completely balanced and, therefore, very high speed gain reduction is made possible without overshooting and instability. Furthermore, this type of automatic gain control circuit has very low distortion because of the distortion reducing properties of a negative feedback loop. The circuit can be operated at higher audio level than conventional automatic gain control circuits and thereby minimizes difficulties arising from noise, microphonics, and other causes.

While I have described a particular embodiment of my invention, other applications will readily be apparent to those skilled in the art. I do not, therefore, desire my invention to be limited to the particular circuit arrangement illustrated and described and I intend by the appended claims to cover all modifications that fall within the spirit and scope of my invention.

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

1. An automatic gain control system including an electronic amplifier having a feedback path connected between the output and the input thereof, a bridge circuit connected in said feedback path and having electron discharge devices in two arms thereof, means for biasing said devices to balance said bridge circuit when the output signal intensity of said amplifier is below a predetermined value to render said feedback path substantially balanced, and means dependent upon intensities of the output signal above said predetermined value and arranged to produce a unidirectional potential to vary the bias on said devices and unbalance said bridge for controlling the amount of feedback in accordance with signal intensity.

2. An automatic gain control system including an electronic amplifier having a feedback circuit connected between the output and input thereof, said feedback circuit being arranged to supply energy from said output circuit to said input circuit in degenerative phase, a bridge circuit connected in said feedback circuit and having electron discharge devices in two arms thereof, means for biasing said devices to balance said bridge when the output signal intensity of said amplifier is below a predetermined value to render said feedback circuit substantially balanced whereby the intensity of the output signal increases linearly with respect to that of the input signal up to said predetermined value, and means dependent upon intensities of the output signal above said predetermined value and arranged to produce a unidirectional potential to vary the bias on said devices and unbalance said bridge for controlling the amount of feedback in accordance with signal intensity to maintain the output signal intensity substantially constant above said predetermined value.

3. An automatic gain control system including an electronic amplifier having a feedback circuit connected between the output and the input thereof, said circuit including a bridge connected therein and comprising resistance elements forming two arms thereof and electron discharge devices forming the other two arms thereof, said bridge being connected in said feedback circuit so that one diagonal of the bridge is connected

across the output of said amplifier and the other diagonal thereof is connected across the input of said amplifier, means for biasing said devices to balance said bridge when the intensity of the signal at the output of said amplifier is below a predetermined value to render said feedback circuit substantially inoperative, and means dependent upon intensities of the output signal above said predetermined value and arranged to produce a unidirectional potential to vary the bias on said devices and unbalance said bridge for controlling the amount of feedback in accordance with signal intensity.

4. An automatic gain control system including an electronic amplifier comprising at least one pair of electron discharge devices connected in push-pull relation, each of said devices having an anode and a cathode and a control electrode, an output circuit connected between the anodes of a pair of said devices, an input circuit connected between the control electrodes of a pair of said devices, a feedback circuit including a bridge connected between said output circuit and said input circuit, resistance elements comprising two arms of said bridge and electron discharge devices comprising the other two arms of said bridge, one diagonal of said bridge being connected between said anodes in said output circuit and the other diagonal of said bridge being connected across the input circuit of said amplifier, means for biasing said devices in said bridge to balance said bridge when the output signal intensity of said amplifier is below a predetermined value to render said feedback circuit inoperative, and means dependent upon intensities of the output signal above said predetermined value for changing the bias of said devices of said bridge to unbalance said bridge and vary the feedback in accordance with output signal intensity.

5. An automatic gain control system including an electronic amplifier comprising at least one pair of electron discharge devices connected in push-pull relation, each of said devices having an anode and a cathode and a control electrode, an output circuit connected between the anodes of a pair of said devices, an input circuit connected between the control electrodes of a pair of said devices, a resistance connected between the cathodes of said last mentioned pair of devices, a feedback circuit comprising a bridge having one diagonal connected across said output circuit and its other diagonal connected across a portion of said resistance, and means dependent upon the intensity of the signal at said output for varying the balance of said bridge to control the amount of feedback through said feedback circuit.

6. An automatic gain control system including an electronic amplifier comprising at least one pair of electron discharge devices connected in push-pull relation, each of said devices having an anode and a cathode and a control electrode, an output circuit connected between the anodes of a pair of said devices, an input circuit connected between the control electrodes of a pair of said devices, a resistance connected between the cathodes of said last mentioned pair of devices, a feedback circuit comprising a bridge having one diagonal connected across said output circuit and its other diagonal connected across a portion of said resistance, said bridge including two arms having electron discharge devices therein, means for biasing said devices in said bridge to balance said bridge and render said feedback circuit inoperative, and means dependent upon intensities

of the signal at the output of said system above a predetermined value for varying the bias on said devices in said bridge to unbalance said bridge and render said feedback circuit operative and for controlling the amount of feedback in accordance with the signal intensity.

7. An automatic gain control system including an electronic amplifier comprising at least one pair of electron discharge devices connected in push-pull relation, each of said devices having an anode and a cathode and a control electrode, an output circuit connected between the anodes of a pair of said devices, an input circuit connected between the control electrodes of a pair of said devices, a resistance connected between the cathodes of said last mentioned pair of devices, a degenerative feedback circuit comprising a bridge having one diagonal connected across said output circuit and its other diagonal connected across a portion of said resistance, said bridge including two arms having electron discharge devices therein, means for biasing said devices in said bridge to balance said bridge and render said feedback inoperative whereby the output signals of said amplifier vary linearly with respect to the input signals up to a predetermined value of output signal intensity, and means including a rectifier associated with the output circuit and dependent upon intensity of the output signal above said predetermined value for varying the bias on said devices in said bridge to unbalance said bridge and render said feedback circuit operative to maintain the intensity of the signals at said output substantially constant.

8. An automatic gain control system including an electronic amplifier having a feedback circuit connected between the output and the input thereof, said circuit including a bridge connected therein and comprising resistance elements forming two arms thereof and electron discharge devices forming the other two arms thereof, said bridge being connected in said feedback circuit so that one diagonal of the bridge is connected across the output of said amplifier and the other diagonal thereof is connected across the input of said amplifier, means for biasing said devices to balance said bridge when the intensity of the signal at the output of said amplifier is below a predetermined value to render said feedback circuit substantially inoperative, means dependent upon intensities of the output signal above said predetermined value and arranged to produce a unidirectional potential to vary the bias on said devices and unbalance said bridge for controlling the amount of feedback in accordance with signal intensity, said last mentioned means comprising a rectifier associated with the output of said amplifier for producing a unidirectional potential proportional to the intensity of the output signal and means for biasing said rectifier to prevent operation thereof when said output signal is below said predetermined value.

9. An automatic gain control system including an electronic amplifier having a feedback circuit connected between the output and the input thereof, said feedback circuit including a bridge connected therein and comprising resistance elements forming two arms thereof and electron discharge devices forming the other two arms thereof, said bridge being connected in said feedback circuit so that one diagonal of the bridge is connected across the output of said amplifier and the other diagonal thereof is connected across the input of said amplifier, each of said devices having an anode and a cathode

and a control electrode, means for biasing the control electrodes of said devices to balance said bridge when the intensity of the signal at the output of said amplifier is below a predetermined value to render said feedback circuit substantially inoperative, and means dependent upon intensities of the output signal above said predetermined value and arranged to produce a unidirectional potential to vary the bias simultaneously on the control electrodes of both said devices and unbalance said bridge for controlling the amount of feedback in accordance with signal intensity.

10. An automatic gain control system including an electronic amplifier having a feedback circuit connected between the output and the input thereof, said circuit including a bridge having two arms each comprising a resistance element and two arms each comprising a resist-

5 ance element and an electron discharge device in series therewith, said bridge being connected in said feedback circuit so that one diagonal of the bridge is connected across the output of said amplifier and the other diagonal thereof is connected across the input of said amplifier, means for biasing said devices to balance said bridge when the intensity of the signal at the output of said amplifier is below a predetermined value to render said feedback circuit substantially inoperative, and means dependent upon intensities of the output signal above said predetermined value and arranged to produce a unidirectional potential to vary the bias on said devices and unbalance said bridge for controlling the amount of feedback in accordance with signal intensity.

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