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2,428,039

FEEDBACK AMPLIFIER

Filed June 20, 1942

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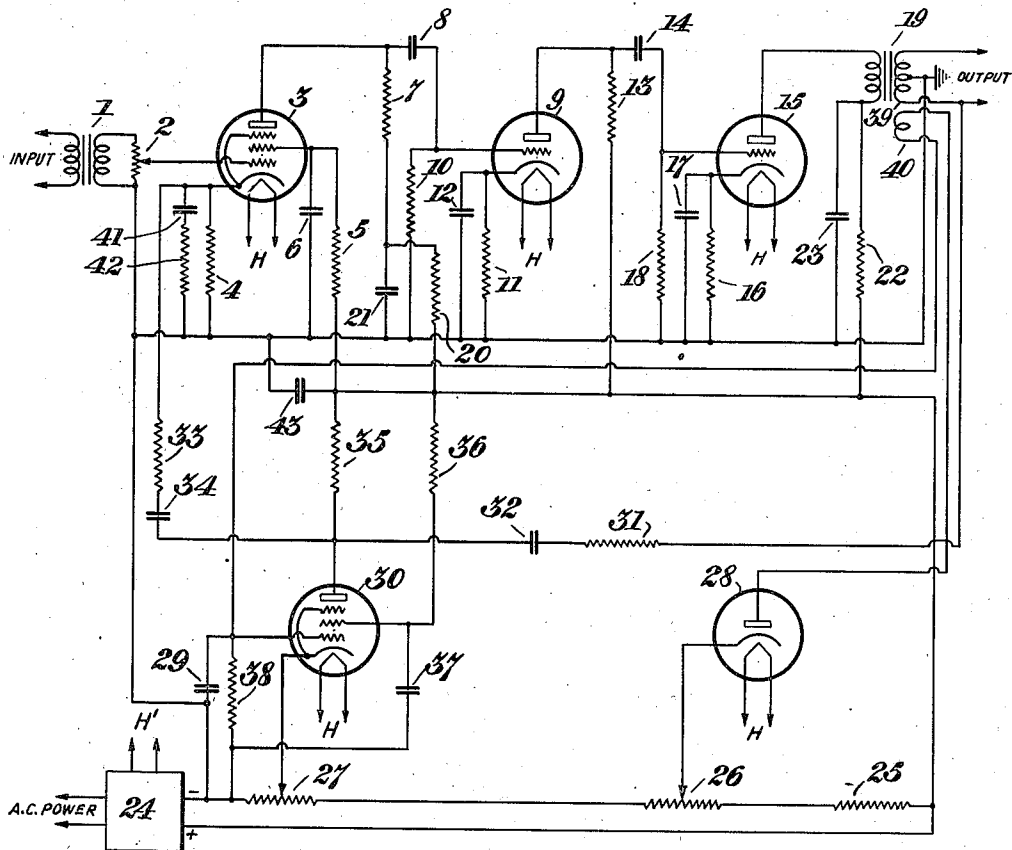


Fig. 1.

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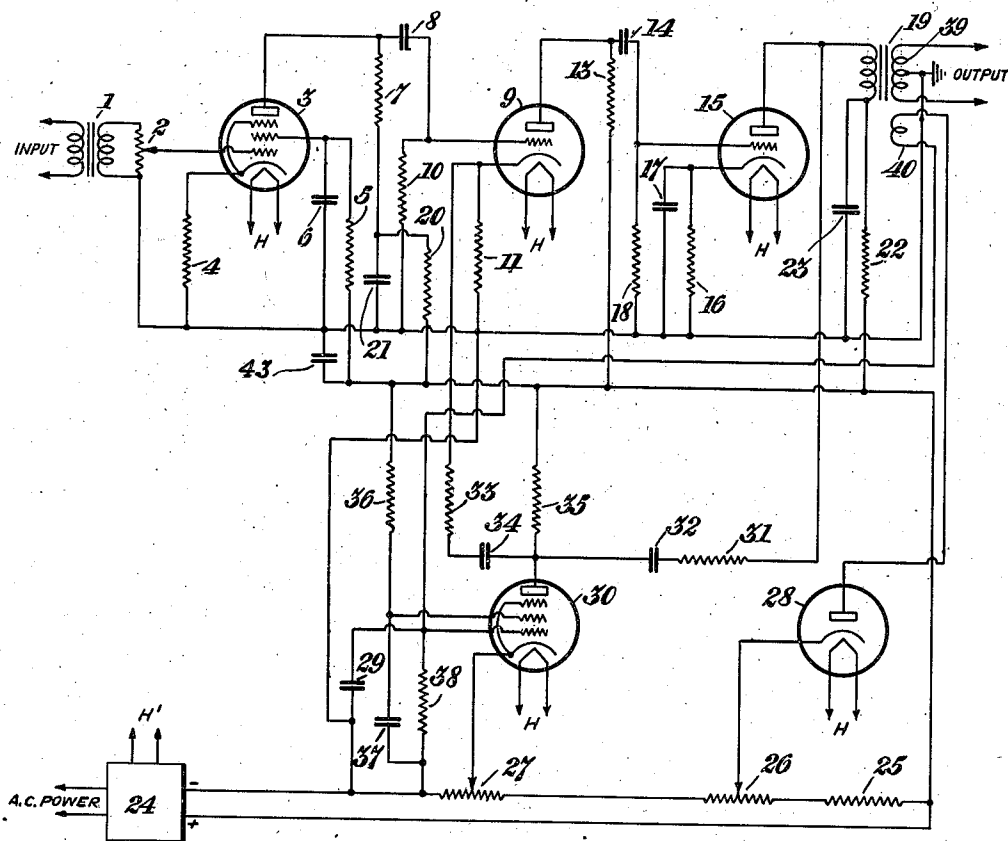


Fig. 2.

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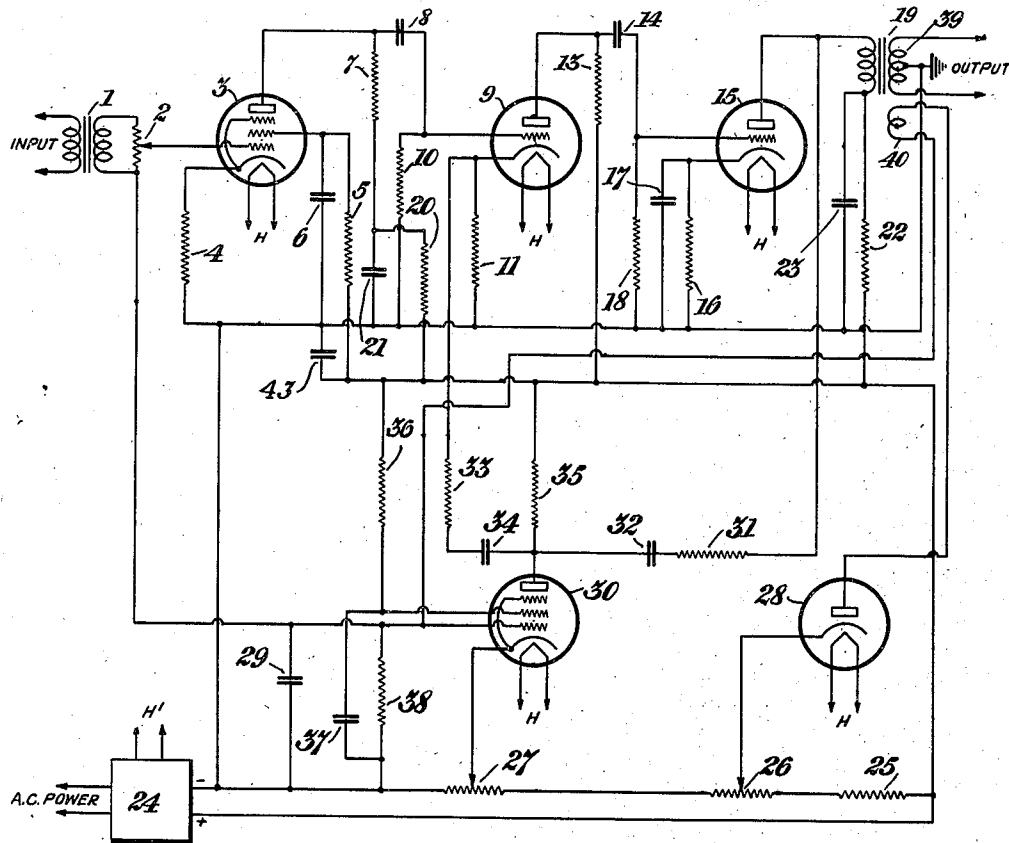


Fig. 3.

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4 Sheets-Sheet 4

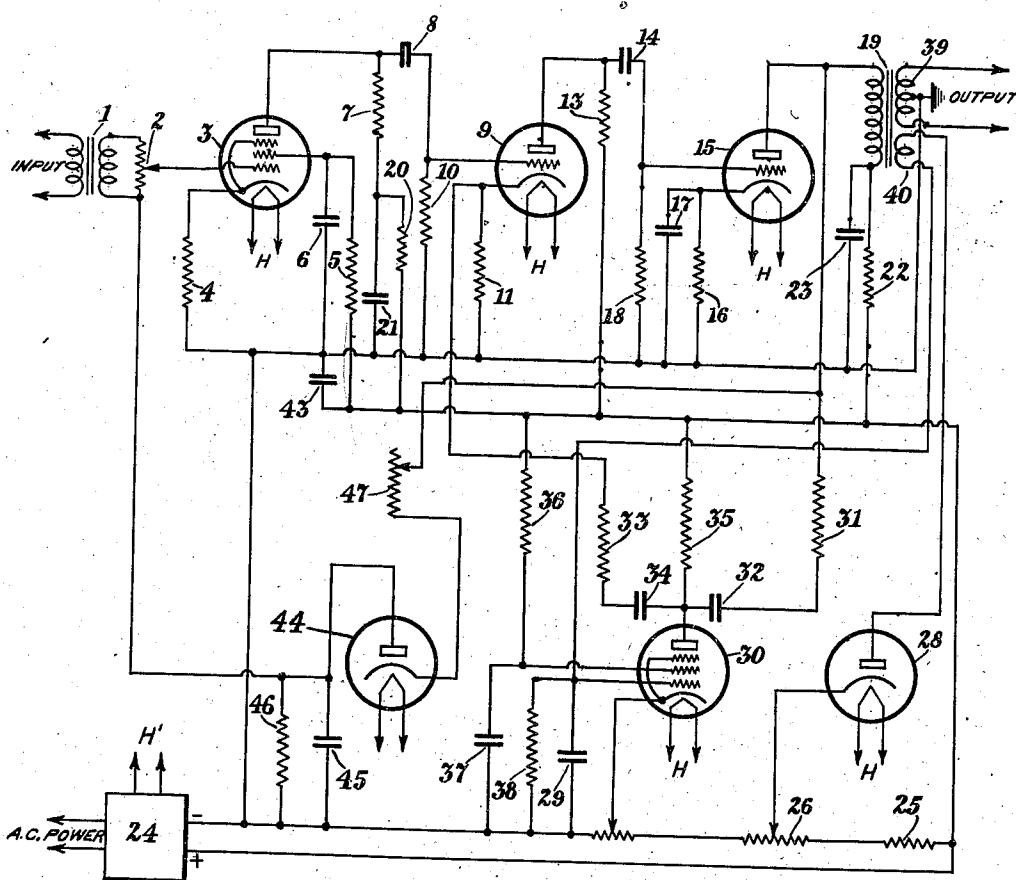


Fig. 4.

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FEEDBACK AMPLIFIER

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15 Claims. (Cl. 179—171)

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This invention relates to amplifiers and particularly to amplifiers having feedback connections for controlling the gain. The object of this invention is to provide an efficient feedback and gain control circuit which will reduce the gain of the amplifier during the duration of an unusually high amplitude signal, so as to prevent distortion.

In accordance with my invention, I reduce the gain of an amplifier when an especially high amplitude signal is momentarily present, by means of a reverse feedback connection between the output and the input of the amplifier so connected that when the signal strength is increased above a certain level, the gain of the amplifier is decreased. I accomplish this by placing in the feedback circuit a shunt comprising a variable μ tube whose impedance is dependent on a D. C. control voltage derived from the amplifier output. The invention will be better understood from the following description and the accompanying drawing of which

Fig. 1 illustrates a system embodying the invention;

Fig. 2 illustrates a system using a variation in accordance with the invention;

Fig. 3 shows another variation of the invention; and

Fig. 4 illustrates another modification.

Referring to Fig. 1 there is shown a vacuum tube amplifier comprising an input transformer 1 adapted to have applied to it electric signals of varying amplitude. The rheostat 2 connected across the transformer output may be a manually operable gain adjustment device. Tube 3 is an amplifier receiving energy from the input transformer, the tube 3 having connected with it a cathode resistor 4, a screen resistor 5 with a by-pass condenser 6, a plate resistor 7, and a series coupling capacitor 8 to the control grid of the succeeding amplifier tube 9. Tube 9 similarly has connected with it a grid resistor 10, cathode resistor 11 with by-pass condenser 12, a plate resistor 13 and a series coupling capacitor 14 leading to the control grid of a third amplifier tube 15. Tube 15 likewise has connected with it a cathode resistor 16, by-pass condenser 17, grid resistor 18, and has an output transformer 19.

The anode current for all tubes is supplied by a power supply unit 24 which takes power from the A. C. lines, rectifies it, and sends the rectified current through the series connected bleeder resistors 25, 26 and 27. Anode current is supplied from the bleeder line to the input stage 3 through resistor 20 by-passed by capacitor 21,

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and to the intermediate stage 9 through resistor 13 and to the output stage through resistor 22 by-passed by capacitor 23. The cathode heater leads marked H may be heated by corresponding leads H' from the power supply.

The reverse feedback and gain control circuit is provided as follows. An auxiliary winding 40 on the output transformer 19 has connected one side to the anode of a diode rectifier 28 whose cathode is biased positive by connection to a point on the bleeder resistor 26, and has its other side connected through a resistor 38 to a more negative point on the power supply bleeder circuit. Resistor 38 is shunted by a capacitor 29 and is connected to the control grid of a variable μ tube 30, the cathode and suppressor electrodes of which are connected to a point on bleeder resistor 27 more positive than the grid, the plate of which is supplied through resistor 35 and the screen is supplied through resistor 36 which is by-passed by capacitor 37. The variable μ tube and resistor 35 constitutes the shunt arm of a T network, one series arm of which is constituted by a resistor 31 and blocking capacitor 32 and the other series arm of which is constituted by a resistor 33 and blocking capacitor 34. These series arms are comprised in the feedback path from the secondary coil 39 of output transformer 19 to the cathode of the input stage 3, the polarity being such that the feedback is negative. Thus the circuit for the feedback current is traced from ground, through one part of the output transformer secondary, through series elements 31, 32, 34 and 33, through the condenser 41 and resistance 42 connected between the cathode and grid of stage 3, and back to ground. At the same time a predetermined amount of feedback current is shunted to ground through resistor 35 and capacitor 43, also through the normal impedance of tube 30 which may be adjusted by variable resistor 27 to the desired operating point. The combination of capacitor 41 with resistors 4 and 42 permit control of the phase of the feedback energy.

When a signal which is too strong is passed through the amplifier or tries to pass through the amplifier, a portion of the output is rectified in diode 28 and charges capacitor 29 negatively with respect to ground, thereby imposing a more negative bias on the control grid of the variable μ tube 30, which increases its internal impedance so that the shunt arm impedance of the T network becomes large and a relatively large part of the negative feedback energy reaches the input of amplifier tube 3, and thus tends to de-

crease the strength of the signal passing through it. When the strong signal has passed, the charge on capacitor 29 occasioned by the rectified current slowly leaks off through resistor 38 thus restoring the system to normal after the passage of the excessive peak signal. In this way temporary peak signal strengths are not permitted to overload and distort the amplifier.

The invention is not limited to any particular values of circuit constants, and these may be so chosen and the cathode bias of tube 30 so adjusted that the internal impedance of tube 30 is normally small in comparison with the impedance of the series arms of the T network; hence by-passing most of the energy returning from the amplifier output to the amplifier input and thereby providing a relatively small amount of feedback.

The invention is not necessarily limited to the particular number of stages shown in Fig. 1 as it may be applied to amplifiers having either more or less than three stages. Furthermore, variations in the reverse feedback and gain control circuit may be made within the scope of the invention. For example, the arrangement may be applied to only some of the stages in a multiple stage amplifier.

Another embodiment of the invention is illustrated in Fig. 2 which is the same as that shown in Fig. 1 except that the resistor 31 is connected to the plate of tube 15 instead of to winding 39, resistor 33 is connected to the cathode of tube 9 instead of to tube 3, and capacitors 12 and 41 and resistor 42, shown in Fig. 1, are omitted from Fig. 2.

A further variation is illustrated in Fig. 3 which illustrates part of the arrangement shown in Fig. 2. The arrangement in Fig. 3 is the same as that in Fig. 2 except that in Fig. 3 tube 3 is a variable μ tube and its grid potential is made subject to automatic gain control by connecting the lower junction of the secondary of transformer 1 and rheostat 2 to the junction of capacitor 29 and coil 40, instead of to ground as in Fig. 2.

Another modification is illustrated in Fig. 4 which is similar to Fig. 3 except that in Fig. 4 there is added an additional diode type rectifier tube 44 having its anode connected with the lower end of resistor 2 and its cathode connected through an adjustable resistor 47 to the anode of the output tube 15. This provides automatic control of the gain of tube 3 dependent on the average signal level. The signal energy is rectified in tube 44 and stored in capacitor 45, the voltage across this capacitor being applied to the grid of the variable μ tube 3. Resistor 46 dissipates the energy stored in capacitor 45, thus tending to increase the gain of tube 3. Adjustable resistor 47 provides means for adjusting the rate of decrease in the gain of tube 3. The amplifier will therefore automatically regulate its gain to maintain a suitable output level. This gain control will usually be relatively slow acting, but the control of the reverse feedback by signals in excess of a predetermined level will be quick acting in order to avoid excessive peak levels.

By the use of this combination, the rectifier 44 and variable μ tube 3 may be adjusted relative to each other to provide a higher gain than if rectifier 23 and its associated variable impedance element were not present. The reason for this is that the operation of rectifier 23 and the negative feedback connection is to remove excessive signal peaks, and this allows the amplifier to be operated at a higher signal level than otherwise.

In addition, other modifications of the invention are possible as may become apparent to those skilled in the art.

The reversed feedback arrangement according to this invention has a great advantage over prior known systems in that in the present system the reversed feedback is most effective when it is most needed, which is when the signal amplitude is greatest. Usually the greatest distortion occurs when the signal amplitude is highest, and this amplifier arrangement reduces the gain of the amplifier by increasing the reversed feedback thereby making use of the property of reversed feedback amplifiers to decrease distortion in proportion to the amount of reversed feedback.

What is claimed is:

1. In combination, an amplifier having an output and an input, a negative feedback connection between the output and the input connected in the phase which tends to oppose the phase of the signal in the amplifier, a variable impedance shunted across said feedback connection and having a determinable impedance-current characteristic, and means for increasing continuously non-linearly the relative impedance of said variable impedance in response to an increase in signal strength.

2. In combination, an amplifier having an output and an input, a negative feedback connection extending between the output and the input in the phase which opposes the signal impressed on the input, a variable μ vacuum tube shunted across said feedback connection and means for applying on said tube a biasing voltage derived from said amplifier output so that the impedance of said tube increases with increased signal strength in the amplifier.

3. A combination according to claim 2 in which the means for applying the biasing potential comprises a rectifier which produces a rectified voltage component dependent on said amplifier output and applies said component to a control electrode of said variable μ tube.

4. A combination according to claim 2 in which said feedback connection contains an impedance in series between said output and said input.

5. In combination, an amplifier having an output and an input, a negative feedback connection between the output and the input in the phase which opposes the signal strength impressed on said input, impedance elements connected in series in said connection, a variable μ tube in shunt with said connection and a rectifier which receives energy from said output and applies a rectified voltage to a control element of said tube, said tube having a normal impedance which is small in comparison with the series impedance in said connection arranged to pass a principal portion of the feedback current through the tube, and a relatively high impedance at rectified voltages produced during output surges, arranged to maintain in the negative feedback connection a portion of the feedback current sufficient for substantial balancing of said surges.

6. In combination, an amplifier having an output and an input, a negative feedback connection containing an impedance between the output and the input, a second impedance containing a variable μ tube in shunt with the first mentioned impedance, a condenser across the input of said variable μ tube, a rectifier connected to produce a rectified current in response to said amplifier output, said rectifier having a circuit which causes said condenser to charge when a voltage surge is

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presented in said amplifier, in the polarity which increases the impedance of said variable μ tube.

7. In combination with a vacuum tube amplifier, a controlling means comprising a negative feedback circuit connected from the output to the input of the amplifier said feedback circuit comprising a T network having series and shunt impedances, the shunt impedance comprising a variable μ tube having a capacitor connected across its input, a rectifier connected to the output of said amplifier to produce therefrom a rectified current, and means for charging said condenser with said current in the polarity which increases the impedance of said variable μ tube when a voltage surge is present.

8. In combination with a vacuum tube amplifier covering a plurality of stages, an output transformer at one stage and a cathode at the input of a preceding stage, a controlling means comprising a negative feedback path connected from the secondary of said output transformer to said cathode, said feedback path comprising a network having series and shunt impedances, the shunt impedance comprising a variable μ tube having a capacitor connected across its input, and a rectifier coupled to the output of said amplifier to produce therefrom a rectified current, a circuit through said rectifier and said condenser for charging said condenser in the polarity which increases said impedance of said variable μ tube when a voltage surge is present.

9. In combination with a vacuum tube amplifier having a plurality of stages including an input control electrode and an output electrode, a controlling means comprising a negative feedback path connected from said output electrode to said control electrode, said feedback path comprising a network having series and shunt impedances, the shunt impedance comprising a variable μ tube having a capacitor connected across its input, a rectifier coupled with the output of said amplifier to produce therefrom a rectified current, and a circuit through said rectifier and said condenser for charging said condenser with said current in the polarity which increases the impedance of said variable μ tube when a voltage surge is present.

10. In combination with a vacuum tube amplifier having a plurality of stages, an output electrode at one stage and a cathode at a preceding stage, a controlling means comprising a negative feedback path connected from said output electrode to said cathode, said path comprising a network having series and shunt impedances, the shunt impedance comprising a variable μ tube and a capacitor connected across its input, a rectifier connected to the output of said amplifier to produce therefrom a rectified current, a circuit through said rectifier and said condenser for charging said condenser in the polarity which increases said impedance of said variable μ tube when a voltage surge is present, and a connection from the input electrode of said preceding stage to the input side of said condenser.

11. Apparatus according to claim 10 in which

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said preceding stage comprises a variable μ tube.

12. In combination, an amplifier having input and output circuits and a variable gain stage, a negative feedback connection having a variable impedance element connected from the output of a stage to the input of a preceding stage, a rectifier responsive to the signal at the amplifier, and a connection for applying the output of said rectifier to control the gain of said variable gain stage and also the impedance of said variable impedance element so as to increase the negative feedback and decrease the gain of said stage when the rectifier output increases.

13. In combination, an amplifier, a negative feedback connection from the point of the amplifier to a preceding point of the amplifier, said connection containing a variable impedance element, a rectifier responsive to a signal at the amplifier, and means for applying the output of said rectifier to said variable impedance element so that when the signal strength increases the negative feedback increases, and a second rectifier responsive to a signal at the amplifier, the output of said second rectifier being connected to control the gain of said amplifier in response to said signal.

14. Apparatus according to claim 13 in which said amplifier contains a variable μ tube in a stage thereof and said second rectifier controls the gain of said variable μ tube.

15. In combination, an amplifier having a variable gain stage, a negative feedback connection from a point of the amplifier to a preceding point of the amplifier, said connection containing a variable impedance element, a rectifier responsive to a signal at the amplifier, and a connection for applying the output of said rectifier to said variable impedance element so that when the signal strength increases the negative feedback increases, and a second rectifier responsive to a signal at the amplifier, a capacity connected to said second rectifier to store output energy from said second rectifier, a resistor connected to dissipate energy stored in said capacitor, and a connection from said capacitor to a control element of said variable gain stage.

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