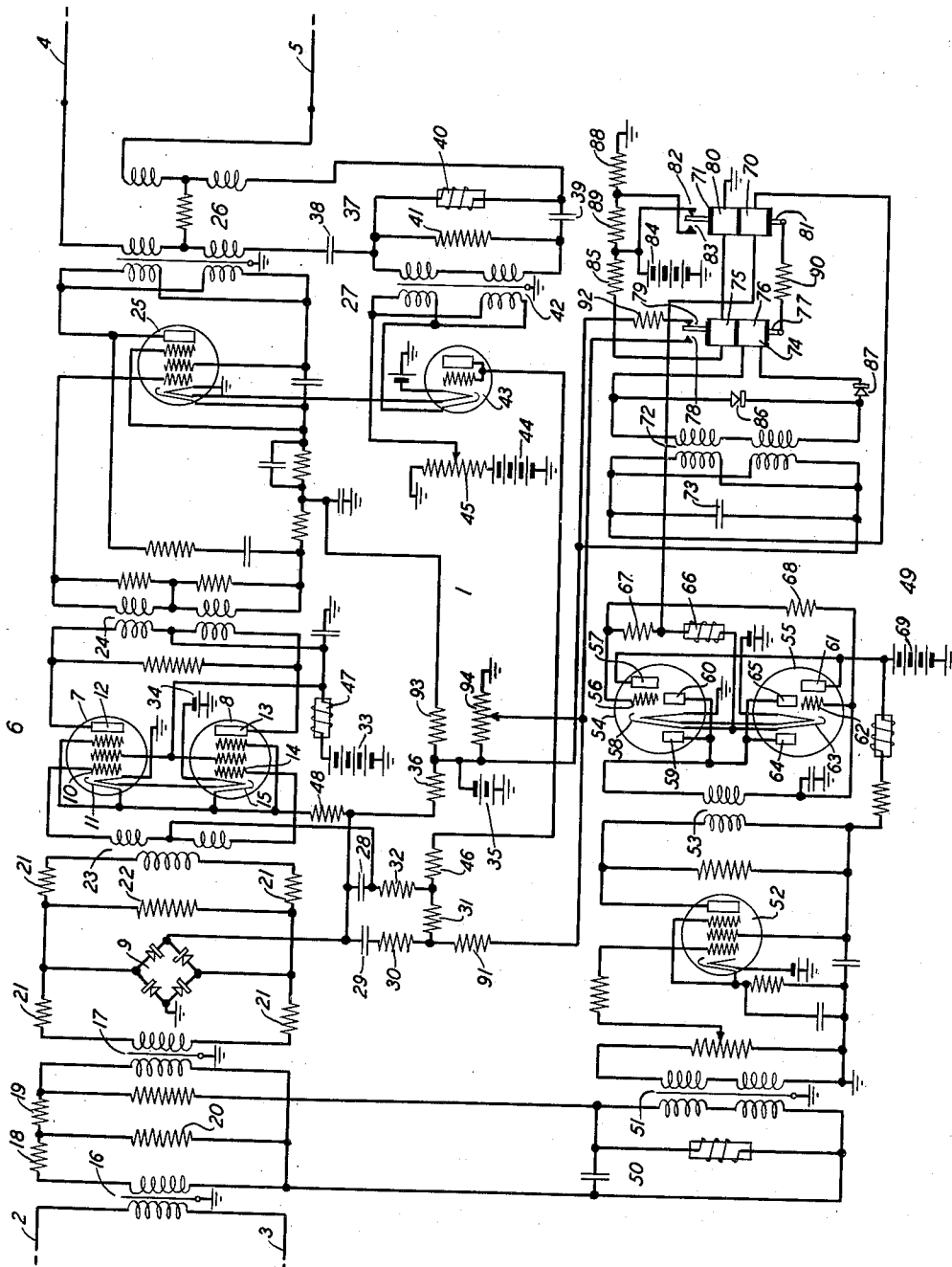


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GAIN CONTROL CIRCUITS

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GAIN CONTROL CIRCUITS

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This invention relates to signal transmission systems and particularly to gain control circuits for controlling the volume on signal transmission systems.

One object of the invention is to provide control circuits having a rectifier and an amplifier with the rectifier controlled by received signals and the amplifier controlled by the rectifier that shall have a negative feedback loop connected to the amplifier for eliminating high frequency currents and for providing efficient terminating impedance for the rectifier circuit.

Another object of the invention is to provide a signal transmission line with control circuits having a diode-triode tube with the diode controlled by signals on the transmission line and the triode controlled by the diode that shall have a negative feedback loop connected to the triode for eliminating high frequency currents and for providing efficient terminating impedance for the diode circuit.

A further object of the invention is to provide gain control circuits for a signal transmission line with a gain increaser circuit having a diode-triode tube with the diode controlled by signals on the transmission line and the triode controlled by the diode that shall have a negative feedback loop connected to the triode for eliminating high frequency currents while preventing extended hang-over in the operation of the triode and for providing efficient terminating impedance for the diode circuit.

On many signal circuits, as for example on circuits having a long radio link, trouble is often experienced at a receiving station by reason of the so-called fading produced during transmission. It is desirable in circuits of this type to correct for the fading and to hold the received signals at substantially constant volume.

In a gain control circuit constructed in accordance with the invention the volume of the signals is held constant under control of a gain increaser circuit and a gain decreaser circuit. The gain increaser circuit is operated to effect increase in the gain in case of low strength signals under control of syllabic frequency impulses. The gain increaser circuit is forward acting and employs diode-triode tubes having a negative feedback loop connected to the triodes to effect efficient operation of the diodes and to eliminate relatively high frequency currents from the gain increaser circuit. The gain decreaser circuit is backward acting. The circuits are improvements on the circuits disclosed in the H. L. Barney et al. appli-

cation Serial No. 284,584, filed July 15, 1939, now Patent No. 2,213,034, issued August 27, 1940.

A vario-repeater is located at a receiving station on the transmission line for varying the gain. The vario-repeater may be in any suitable form and preferably comprises a pair of push-pull tubes of any suitable type and a varistor. The varistor preferably comprises a bridge of copper-oxide elements shunted across the transmission path. The control grids of the two tubes in push-pull relationships are controlled according to the charge on two control condensers. One of the control condensers is relatively small compared to the other condenser. The varistor in the form of a copper-oxide bridge is controlled according to the space current flowing through the tubes in push-pull relationship. When the tubes have large impedance and the space current flow through them is small, the shunting action by the copper-oxide bridge is large. When the tubes have small impedance and the space current flow through them is large, the shunting action effected by the copper-oxide bridge is small.

The backward-acting gain decreaser circuit is provided for impressing a negative charge on the control condensers to lower the gain on the transmission line. The forward-acting gain increaser circuit impresses a positive charge on the control condensers to raise the gain on the transmission line. The gain decreaser circuit and the gain increaser circuit are controlled according to the energy level of the signals on the transmission line.

The gain decreaser circuit which is connected to the transmission line beyond the vario-repeater comprises a high-pass filter which prevents the operation of the gain decreaser circuit by low frequency transients due to unbalanced plate current in the vario-repeater. The low frequency transients might otherwise cause excessive reductions of gain. The filter is connected to a rectifier tube by means of a transformer. The rectifier tube impresses a negative charge on the control condensers to govern the operation of the push-pull tubes in the vario-repeater. The push-pull tubes when operated by the control condensers also control the copper-oxide bridge to lower the gain on the transmission line.

The gain increaser circuit is connected to the transmission line before the vario-repeater and comprises a suitable filter which selects currents having a range of frequencies usually in center portion of the voice frequency range. In systems of transmission where the voice currents of dif-

ferent frequencies are not displaced, the selected frequencies are between 800 and 1600 cycles per second. However, in systems where the voice frequencies have been displaced from their normal position, as is customary in systems of primary transmission, the pass band on the filter is correspondingly displaced. The filter is connected to an amplifier and the amplifier is connected to two diode-triode tubes. The input signals when rectified by the diode portions of the diode-triodes supply a negative bias for controlling the grids of the triodes. A negative feedback loop is connected to the triodes of the diode-triodes for eliminating high frequency currents and for providing efficient terminating impedance for the diodes. The negative feedback loop also insures that the triodes will be operated without an excessive hang-over. A filter in the output circuit of the triodes selects a range of syllabic frequency which is preferably centered around 6 or 8 cycles per second. The syllabic frequency filter is connected by a transformer to a coil of a gain increaser relay. Rectifier elements which are preferably of the copper-oxide type are connected in series and in shunt to the secondary winding of the transformer connected to the syllabic frequency filter. The copper-oxide elements serve not only to insure the operation of the gain increaser relay on the rising portion of a syllabic impulse but also serve to improve the operating characteristics.

The gain increaser relay when operated impresses a positive charge on the control condensers to raise the gain on the transmission line. A gain rate relay which is operated by the output from the triodes of the diode-triodes is provided for reducing the rate of gain increase effected by the gain increaser circuit whenever the signals on the transmission line before the vario-repeater are above a predetermined level. The gain increase is controlled by syllabic impulses on the gain increaser circuit in order to insure against false operation of the gain increaser circuit by noise or static disturbances. The gain increase is controlled only on a rising portion of a syllabic impulse so that in so far as possible the gain increase action may be performed during the initial part of a speech syllable. Thus when the gain is sufficiently high the remainder of the speech syllable may operate the gain decreaser circuit and no further gain increase may take place on the final part of the syllable.

The single figure in the accompanying drawing is a diagrammatic view of gain control circuits constructed in accordance with the invention.

Referring to the drawing, a gain control arrangement 1 at a receiving station is shown having input conductors 2 and 3 and output conductors 4 and 5. The input conductors 2 and 3 are connected to a source of signals varying in intensity and which may be the output of a radio receiver (not shown). The output conductors 4 and 5 may be connected to a telephone line or to a loud-speaker (not shown). It is desired to apply signals of relatively constant intensity to the telephone line or loud-speaker. A vario-repeater 6 comprising two pentode tubes 7 and 8 and a copper-oxide bridge 9 are provided in the path between the input conductors 2 and 3 and the output conductors 4 and 5 for controlling the gain. The tube 7 comprises a control grid 10, an anode 12 and a cathode 11. The tube 8

comprises an anode 13, a control grid 14 and a cathode 15.

The copper-oxide varistor bridge 9 is composed of copper-oxide elements shunted across the transmission path. The input conductors 2 and 3 are connected to the varistor 9 by means of transformers 16 and 17. Resistance elements 18 and 19 are connected in series and resistance element 20 is connected in shunt between the secondary winding of the transformer 16 and the primary winding of the transformer 17. Resistance elements 21 are disposed on each side of the bridge 9 and a resistance element 22 is connected in shunt to the bridge. A transformer 23 connects the pad formed by the varistor 9 and the resistance elements 21 and 22 to the input circuits of the tubes 7 and 8 in push-pull relationship. The output circuits of the tubes 7 and 8 are connected by a transformer 24 to a negative feedback amplifier 25. The output circuit of the amplifier 25 is connected by hybrid coil 26 to the output conductors 4 and 5 and to a gain decreaser circuit 27.

Two control condensers 28 and 29 are provided for controlling the grids 10 and 14 of the tubes 7 and 8. The condenser 28 is relatively small compared to the condenser 29 and serves to effect quick changes in gain of short duration on the transmission path. The larger condenser 29 serves to control the tubes 7 and 8 in the case of prolonged changes in volume on the transmission path. The condenser 29 in series with resistance elements 30, 31 and 32 is connected in shunt to the condenser 28 so that small charges impressed on the condenser 28 may be transferred to the larger condenser 29. A battery 33 is provided for supplying anode potential to the tubes 7 and 8. The battery 33 also provides potential for governing the operation of the copper-oxide bridge 9. A battery 34 supplies current for heating the cathodes 11 and 15 of the tubes 7 and 8. A battery 35 supplies potential for energizing the copper-oxide bridge 9. The circuit for energizing the bridge 9 may be traced from grounded battery 35 through a resistance element 36, bridge 9 and ground return to the battery 35.

The gain decreaser circuit 27 comprises a filter 37 connected to the hybrid coil 26. The filter 37 comprises two condensers 38 and 39, an inductance 40 and resistance element 41. The filter 37 is connected by a transformer 42 to a rectifier tube 43. The rectifier tube 43 is connected to the control condenser 28. The circuit from the tube 43 for charging the control condenser 28 may be traced from grounded battery 44 through resistance element 45, secondary windings of the transformer 42, rectifier tube 43, resistance element 46, resistance element 32, condenser 28, resistance element 36, battery 35 and ground return to the battery 44. This circuit serves to charge the condenser 28 in a manner to impress negative potential on the grids 10 and 14 of the tubes 7 and 8.

In case the signals on the transmission path beyond the vario-repeater 6 go above a predetermined level, the rectifier tube 43 supplies potential for charging the control condenser 28 with negative potential. The negative potential on the control condenser 28 is impressed on the control grids 10 and 14 of the tubes 7 and 8 to increase the impedance of the tubes and decrease the space current. The copper-oxide bridge 9 is controlled in accordance with the space current flow through the tubes 7 and 8. The circuit for the space current through the tubes 7 and 8 may

be traced from the grounded battery 33 through choke coil 47, primary windings of the transformer 24 in parallel, anodes 12 and 13, cathodes 11 and 15, resistance element 48, resistance element 36, battery 35 and ground return to the battery 33. The potential drop across the resistance element 36 formed by the space current flow through the tubes 7 and 8 cooperates with the potential drop across the resistance element 36 in circuit with the battery 35 to control the copper-oxide bridge 9. The current flow through the bridge 9 from the battery 35 lowers the impedance of the bridge across the transmission path. The current flow from the battery 33 through the tubes 7 and 8 and resistance element 36 produces a potential drop across the resistance element which reduces the effect of the battery 35 on the bridge. Thus, the bridge 9 is controlled according to the space current flow through the tubes 7 and 8. If the space current flow through the tubes 7 and 8 is reduced by impressing negative potential on the grids 10 and 14, as in the case under consideration, then the resistance of the bridge is reduced to increase the shunting action thereof.

A gain increaser circuit 49 is provided for impressing a positive charge on the control condensers 28 and 29 to increase the gain on the transmission path effected by the vario-repeater 6. The gain increaser circuit 49 comprises a filter 50 connected to a transmission path between the transformers 16 and 17 and ahead of the vario-repeater 6. The filter 50 selects a frequency band within the voice frequency range which is centered around a frequency of the order of 1200 cycles. The filter 50 is connected by a transformer 51 to the input circuit of an amplifier 52 of any suitable type. The output circuit of the amplifier 52 is connected by a transformer 53 to the diode parts of two diode-triode tubes 54 and 55.

The diode-triode 54 comprises a control grid 56, an anode 57, a cathode 58 and two auxiliary anodes 59 and 60. The diode-triode 55 comprises an anode 61, a control grid 62, a cathode 63 and two auxiliary anodes 64 and 65. The circuit through the diodes of the diode-triodes 54 and 55 may be traced from one terminal of the secondary winding of the transformer 53 through auxiliary anodes 59 and 60 and cathode 58 in parallel to auxiliary anodes 64 and 65 and cathode 63 through impedance element 66, resistance element 67 and resistance element 68 to the other terminal of the secondary winding for the transformer 53. The potential drop across the resistance element 67 serves to control the triode of the tube 54 and the potential drop across the resistance elements 67 and 68 controls the triode of the tube 55.

The output circuit for the triodes of the tubes 54 and 55 may be traced from a grounded battery 69 through anodes 61 and 57 in parallel, cathodes 63 and 58, impedance element 66, coil 70 of a gain rate relay 71, primary windings of a transformer 72, battery 35 and ground return battery 69. The impedance element 66 is in the input circuits for the triodes of the tubes 54 and 55 and also in the output circuits for the tubes 54 and 55. The impedance element 66 has a high impedance at relatively high frequencies and a negligible impedance at low frequencies such as syllabic frequencies of 6 to 8 cycles. This impedance element 66 forms a part of a negative feedback loop for the triodes of the tubes 54 and 55 and serves to eliminate high frequency cur-

rents and to provide efficient terminating impedance for the diodes of the tubes 54 and 55.

A condenser 73 connected across the primary winding of the transformer 72 forms a filter for selecting impulses of syllabic frequency. The transformer 72 is connected to a gain increaser relay 74 which impresses a positive charge on the control condensers 28 and 29 to lower the negative potential on the grids 10 and 14 of the tubes 7 and 8. The gain increaser relay 74 comprises a holding coil 75, an operating coil 76, and an armature 77, which operates between the contact members 78 and 79. The gain rate relay 71, which is controlled by the output of the diode-triode tubes 54 and 55 comprises a biasing coil 80, the operating coil 70, and an armature 81 which operates between contact members 82 and 83. The biasing coils 75 and 80 for the gain increaser relay and gain rate relay are energized from the battery 84 through a resistance element 85.

A copper-oxide resistor 86 is connected in shunt to the secondary winding of the transformer 72 and a copper-oxide resistor 87 is connected in series between the transformer 72 and the coil 76 of the gain increaser relay 74 to insure operating the relay 74 on the rising portion of the syllabic impulse and to improve the operating characteristic. The gain increaser relay when operated moves the armature 77 from engagement with the contact member 79 into engagement with the contact member 78. Upon engagement of the armature 77 with the contact member 78 a circuit is completed for impressing a positive charge on the control condensers 28 and 29. This circuit may be traced from ground through resistance elements 88 and 89, contact member 82, armature 81, resistance element 90, armature 77, contact member 78, resistance element 91, resistance element 31, resistance element 32, condenser 28, resistance element 36, battery 35 and ground return to resistance element 88. The resistance elements 88 and 89 in the above-traced circuit have potential impressed thereon from the grounded battery 84. The battery 35 is connected through a resistance element 92 to contact member 79 for impressing negative potential on the armature 77 when in released position. The impressing of a negative charge on the armature 77 of the relay 74 prevents the leakage of any positive charge to the contact member 78 from the resistance elements 88 and 89. A resistance element 93 provides a leak for the charge on the control condensers 28 and 29. The voltage finally arrived at is controlled by the potential drop across a resistance element 94.

The operating coil 70 for the gain rate relay 71 is connected to the output circuits of the triodes in the tubes 54 and 55 in order to be operated in accordance with the strength of the signals on the transmission line. The gain rate relay 71 is normally held in operated position with the armature 81 in engagement with the contact member 82. When the strength of the signals on the transmission line is raised above a predetermined point, the gain rate relay is released and the armature 81 engages the contact member 83. Negative potential is impressed on the grids 56 and 62 of the tubes 54 and 55 from the coupling resistances 67 and 68 so that the output current from the tubes 54 and 55 is reduced as the strength of the signals on the transmission line increases. When the gain rate relay 71 is released and the armature 81 engages

contact member 83, the potential drop across only the resistance element 88 is impressed on the condensers 28 and 29 upon operation of the gain control relay 74. By this means the rate of gain change is varied according to the strength of the signals on the transmission line.

When signals are received from the transmission path the filter 50 selects the desired range of voice frequency components which are amplified by the amplifier 52. The output from the amplifier 52 is rectified by the diode portions of the diode-triode tubes 54 and 55. The diodes are coupled to the input circuits of the triodes by means of the coupling resistance elements 67 and 68 to supply negative bias to the control grids of the triodes. The negative feedback loop for the triodes, which includes the impedance element 66, serves to eliminate relatively high frequency currents in the input circuits of the triodes. The negative feedback loop also serves to provide efficient terminating impedance for the diodes. The syllabic impulses selected from the output circuit of the tubes 54 and 55 control the operation of the gain increaser relay 74 for charging the condensers 28 and 29 with potential to lower the negative potential on the grids 10 and 14 of the tubes 7 and 8. Lowering the negative potential on the control grids of the tubes 7 and 8 increases the space current flow through the tubes and lowers the impedance of the tubes. An increase in the space current flow through the tubes 7 and 8 lowers the shunting action of the copper-oxide bridge 9 across the transmission path. Each time the gain increaser relay 74 is operated it impresses an increment of positive charge on the control condensers 28 and 29. This progressively decreases the negative charge on the control condensers and on the grids 10 and 14 of the tubes 7 and 8. If the signals on the transmission line before the vario-repeater are above a predetermined level, the gain rate relay 71 is operated to decrease the rate at which the control condensers 28 and 29 are charged.

Modifications in the circuits and in the arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In a signal system, an amplifier having a negative feedback loop, impedance means in said feedback loop which varies with the frequency of the currents carried thereby, a rectifier terminated by the impedance across said feedback loop, said terminating impedance increasing the rectifier efficiency without producing hangover in the amplifier operation and eliminating high frequencies from the amplifier circuit and means for applying waves of a frequency range including relatively high frequency waves to said rectifier, said rectifier output including frequencies for which said feedback loop has high and low loop gains.

2. In a signal system, an amplifier having a negative feedback loop, impedance means in said feedback loop which varies with the frequency of the currents carried thereby, a rectifier terminated by the impedance across said feedback loop, said terminating impedance being low at relatively high frequencies and high at relatively low frequencies to increase the efficiency of said rectifier without hangover in the amplifier operation to eliminate high frequencies in the amplifier circuit, and means for applying waves of a frequency range including relatively high frequency waves to said rectifier, said rectifier out-

put including frequencies for which said feedback loop has low and high loop gains.

3. In a signal system, a diode-triode having the input circuit of the triode coupled to the diode circuit, a negative feedback loop for said triode, impedance means in said loop which varies with the frequency of the currents carried thereby, said diode being terminated by the impedance across said feedback loop to increase the efficiency of said diode without hangover operation and to eliminate high frequencies in the triode circuit, and means for applying waves of a frequency range including relatively high frequency waves to said diode, said diode output including frequencies for which said feedback loop has high and low loop gains.

4. In a signal system, a diode-triode having the input circuit of the triode coupled to the diode circuit, a negative feedback loop for said triode, impedance means in said loop which varies with the frequency of the currents carried thereby, said diode being terminated by the impedance across said feedback loop and said impedance across said loop being low at relatively high frequencies and high at relatively low frequencies to increase the efficiency of the diode without hangover, and means for applying waves of a frequency range including relatively high frequency waves to said diode, said diode output including frequencies for which said feedback loop has low and relatively high loop gains.

5. In combination, a vario-repeater for controlling the gain on a signal transmission line, and a gain increaser circuit connected to said line for governing said vario-repeater, said gain increaser circuit comprising a diode-triode tube, the diode of said tube rectifying the signals received from the transmission line, means for controlling the triode according to the operation of the diode, means comprising a negative feedback loop for said triode, the impedance across said feedback loop having low impedance at relatively high frequencies and high impedance at relatively low frequencies for terminating the diode circuit to increase the diode efficiency without hangover action by the triode and for eliminating high frequency currents.

6. In combination, a vario-repeater for controlling the gain on a signal transmission line, and a gain increaser circuit connected to said line for governing said vario-repeater, said gain increaser circuit comprising a diode-triode tube, the diode of said tube rectifying the signals received from said transmission line, means for controlling the triode according to the operation of the diode, means comprising a negative feedback loop for said triode to eliminate high frequency currents and to increase the diode efficiency without hangover operation, and means controlled by the output current from the triode to govern the vario-repeater.

7. In combination, a vario-repeater for controlling the gain on a signal transmission line, and a gain increaser circuit connected to said line for governing said vario-repeater, said gain increaser circuit comprising a diode-triode tube, the diode of said tube rectifying the signals received from said transmission line, means for controlling the triode according to the operation of the diode, an impedance element in the output and input circuits of the triode and the diode circuit for providing a negative feedback, said negative feedback providing terminating impedance for the diode to increase the efficiency thereof without hangover action by the triode and for

eliminating high frequency currents, and means controlled by the output current from the triode for governing said vario-repeater to raise the gain on the transmission line.

5 8. In combination, a vario-repeater for controlling the gain on a signal transmission line, and a gain increaser circuit controlled by the signals on the line for governing said vario-repeater, said gain increaser circuit comprising a
10 diode-triode tube, the diode of said tube rectifying the signals received from said transmission line, means for operating the triode according to the operation of the diode, an impedance element in the output and input circuits of the triode
15 and the diode circuit for providing a negative feedback, said negative feedback providing high terminating impedance for the diode to increase the efficiency thereof without hangover action by the triode and eliminating high frequencies from
20 the triode, and means controlled by the output current from the triode for governing said vario-repeater to raise the gain on the transmission line and for controlling the rate at which the gain change is effected.

25 9. In combination, a vario-repeater for controlling the gain on a signal transmission line, and a forward-acting gain increaser circuit for governing said vario-repeater, said gain increaser circuit comprising two diode-triode tubes, the
30 diodes of said tubes rectifying the signals received from said transmission line, coupling means between the diode circuits and the input circuits of the triode to control the triodes of said tubes, an impedance element in the output
35 and input circuits of said triodes and the diode circuits for providing a negative feedback loop, said feedback loop providing high terminating impedance for the diodes to increase the efficiency thereof without hangover action and eliminating
40 high frequency currents from the triode circuits, and means controlled by the output current from the triodes for governing said vario-

repeater to raise the gain on the transmission line.

10. In combination, a vario-repeater for controlling the gain on a signal transmission line, a backward-acting circuit for governing said
5 vario-repeater to lower the gain on the transmission line and a forward-acting gain increaser circuit controlled by signals on the line for governing said vario-repeater, said gain increaser circuit comprising a diode-triode tube, the diode
10 of said tube rectifying the signals received from said transmission line, means for controlling said triode according to the operation of said diode, an impedance element in the output and input circuits of the triode and the diode circuit for
15 providing a negative feedback at high frequencies from the triode to the diode to eliminate high frequency currents, a syllabic frequency filter connected to the triode output circuit, means comprising a gain increaser relay controlled by
20 the output from said filter for operating said vario-repeater, and means comprising a gain rate relay connected to the triode output circuit for changing the rate of gain by the gain rate relay according to the triode output.

25 11. In combination, a vario-repeater for controlling the gain on a signal transmission line and a gain increaser circuit connected to said line for governing said vario-repeater, said gain increaser circuit comprising a diode-triode, the
30 diode of said tube rectifying the signals from the transmission line, means for impressing negative potential on the grid of the triode according to the operation of the diode, means comprising a negative feedback loop connected to said triode
35 for eliminating relatively high frequency currents from the triode input circuit and for increasing the efficiency of the diode while limiting the hang-over time of the potential impressed on the grid of the triode to a relatively
40 short period.

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