

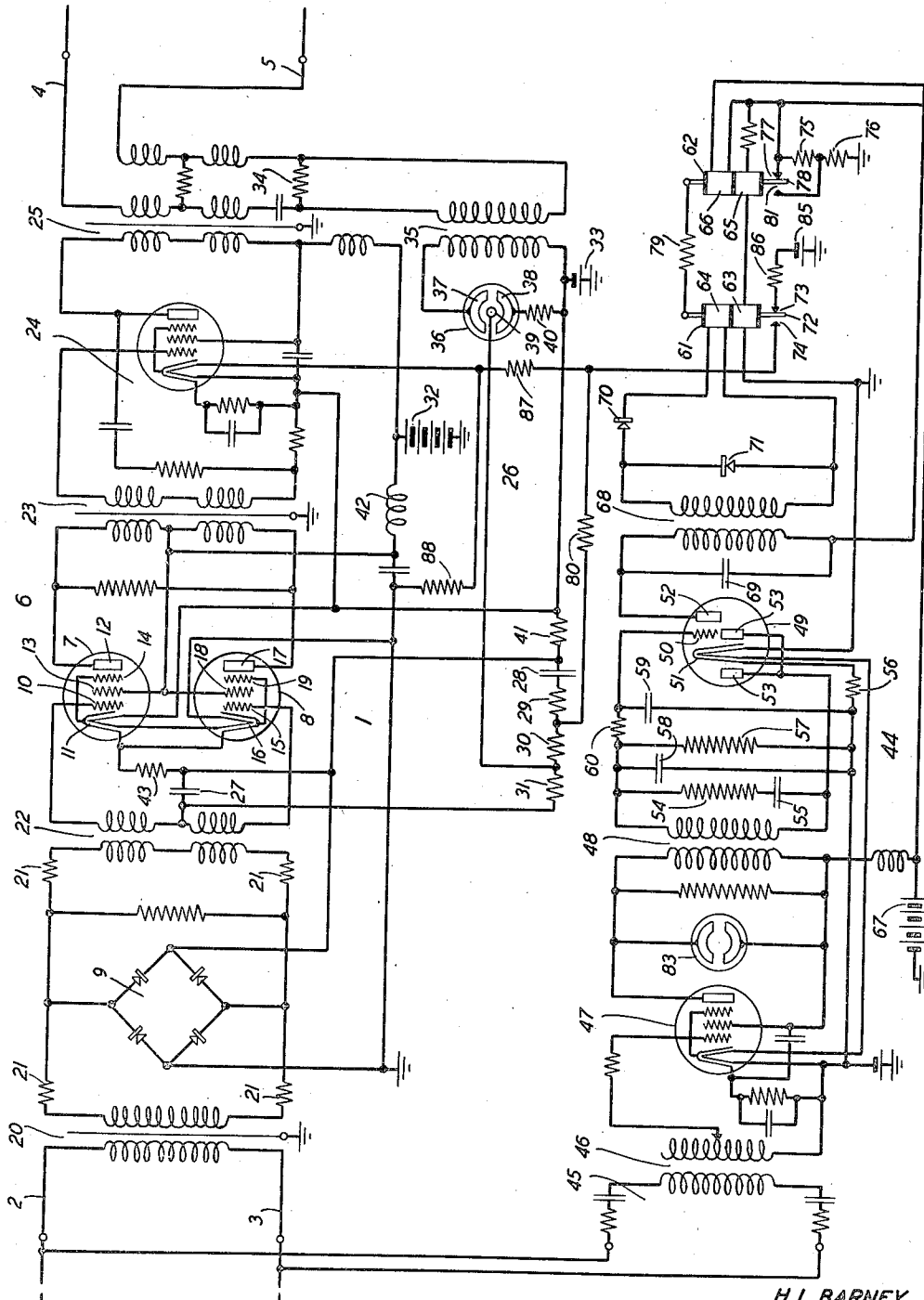
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GAIN CONTROL CIRCUITS

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GAIN CONTROL CIRCUITS

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

5 An object of the invention is to provide gain control circuits for a signal line that shall have a forward-acting gain increaser circuit under control of syllabic impulses to raise the gain on the line.

10 Another object of the invention is to provide gain control circuits for a signal transmission line that shall have a forward-acting circuit for changing the rate of gain increase.

15 Another object of the invention is to provide gain control circuits for a receiving station on a signal transmission line that shall have a forward-acting gain increaser circuit under control of syllabic impulses to raise the gain of the signals received over the transmission line only on the rising parts of the syllabic impulses.

20 A further object of the invention is to provide gain control circuits for maintaining substantially constant volume at a receiving station on a signal transmission line that shall have a backward-acting gain decreaser circuit for controlling a vario-repeater on the line to lower the gain in case the signals go above a predetermined level and that shall have a forward-acting gain increaser circuit under control of syllabic impulses to raise the gain of the signals received over the transmission line only on the rising part of the syllabic impulses.

25 On long signal circuits and particularly 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 signal circuits of the above-indicated character to correct for the fading and to hold the received signals at substantially constant volume.

30 In gain control circuits constructed in accordance with the invention, gain increase in the case of low received signals is effected at a relatively quick rate under control of syllabic frequency impulses. The gain controlling operation is only effected under control of the rising portion of a syllabic impulse. Furthermore, the gain increase is effected by the gain increaser circuit at different rates, depending on the input signal amplitude.

35 At the receiving station on a long transmission path a vario-repeater is provided 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 connected in push-pull arrangement are controlled according to the charge on two control
40 condensers. One of the condensers is relatively

small compared to the other condenser. Two condensers of this type for controlling a vario-repeater are disclosed in the patent to S. Doba, Jr., No. 2,156,622, May 2, 1939. 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 effected by the copper-oxide bridge is large.

45 A backward-acting gain decreaser circuit is provided for impressing a negative charge on the control condensers to lower the gain on the transmission line. A forward-acting gain increaser circuit is provided for impressing 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.

50 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 three-element cold cathode tube by means of a transformer. The three-element cold cathode tube when broken down 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.

55 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 the center portion of the voice frequency range. In systems of transmission where the voice currents of different 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 positions as is customary in systems of primary transmission, the pass-band of the filter is correspondingly displaced. The filter is connected to an amplifier having a limiter of the peak chopper type in the output circuit thereof. The output circuit of the amplifier is connected to the diode portion of a double diode-triode. The input signals, when rectified by the diode portion of the double diode-triode, supply a negative bias for controlling the grid of the triode. A filter in the output circuit of the triode portion of the diode-triode selects a range of syllabic frequency which is preferably centered around

six or eight cycles per second. The syllabic frequency filter is connected by a transformer to a coil of a gain increaser relay. A rectifier element which is preferably of the copper-oxide type is connected in series with the coil of the gain increaser relay in order to effect operation of the relay only on the rising part of a syllabic impulse. A second copper-oxide element is connected in shunt across the circuit of the coil for the gain increase relay to insure that the gain increaser relay is not operated on the falling portion of a syllabic impulse.

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 increase relay which is operated in accordance with the energy value of the syllabic frequency impulses controlling the gain increaser relay 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 a 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 the speech syllable. Thus, when the gain is sufficiently high so that the rest of the speech syllable operates the gain decreaser, no further gain increase is likely to 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 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) to which it is desired to apply signals of a relatively constant intensity. A vario-repeater 6 comprising two tubes 7 and 8 and a copper-oxide bridge 9 is provided in the path between the input conductors 2 and 3 and the output conductors 4 and 5 for controlling the gain effected. The tube 7 comprises a control grid 10, a cathode 11, an anode 12, a screen grid 13 and a suppressor grid 14. The tube 8, which is similar to the tube 7, comprises a control grid 15, a cathode 16, an anode 17, a screen grid 18 and a suppressor grid 19. 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 a transformer 20. Resistance elements 21 are disposed on each side of the bridge 9. A transformer 22 connects the pad formed by the varistor 9 and the resistance elements 21 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 23 to a negative feedback amplifier 24. The output circuit of the amplifier 24 is connected by a "hybrid" coil 25 to the output conductors 4 and 5 and to a gain decreaser circuit 26.

Two control condensers 27 and 28 are provided for controlling the grids 10 and 15 of the tubes

7 and 8. The condenser 27 is relatively small compared to the condenser 28 and serves to effect quick changes in gain of short duration on the transmission path. The larger condenser 28 serves to control the tubes 7 and 8 in the case of prolonged changes in volume on the transmission path. Condenser 28 in series with the resistance elements 29, 30 and 31 is connected in shunt to the condenser 27 so that the small charges impressed on the condenser 27 may be transferred to the larger condenser 28. A battery 32 is provided for supplying anode potential to the tubes 7 and 8. Battery 32 also provides potential for governing the operation of the copper-oxide bridge 9. A battery 33 supplies potential for heating the filaments of the tubes 7 and 8 and the amplifier 24. The battery 33 also supplies potential for biasing the bridge 9.

The gain decreaser circuit 26 comprises a filter 34 connected to the hybrid coil 25. The filter 34 is connected by a transformer 35 to a three-element cold-cathode tube 36. The tube 36 comprises three electrodes 37, 38 and 39. The breakdown circuit for the cold-cathode tube 36 may be traced from one terminal of the secondary winding of the transformer 35 through the electrode 37, electrode 38 and resistance 40 to the other terminal of the secondary winding of the transformer 35. The operating circuit for the cold-cathode tube 36 may be traced from the electrode 39 through resistance 31, condenser 27, resistance 41, and secondary winding for the transformer 35 to the electrode 37 of the tube 36. A shunt circuit, comprising resistance element 31, resistance element 30, resistance element 29 and condenser 28, is connected across the condenser 27. Potential drop across the resistance 41 in the operating circuit of the tube 36 supplies potential for biasing the tube 36. Operation of the control gap immediately starts operation in the main gap for impressing a negative charge on the condenser 27. The potential drop across the resistance 41 is provided by a circuit extending from the battery 33 through the resistance 41, bridge 9 and ground return to other terminals of the battery 33.

In case the signals on the transmission line beyond the vario-repeater 6 go above a predetermined level, the cold-cathode tube 36 is broken down for completing the circuit for charging the control condenser 27 with negative potential. The negative potential on the control condenser 27 is impressed on the grids 10 and 15 of the tubes 7 and 8 to increase the impedance of the tubes and decrease the space current. The bridge 9 is controlled in accordance with the space current flow through the tubes 7 and 8. The circuit for the space current through tubes 7 and 8 may be traced from one terminal of the battery 32 through a choke coil 42, the primary winding of the transformer 23, plates 12 and 17 and cathodes 11 and 16 of tubes 7 and 8, resistance element 43, resistance element 41, battery 33 and ground return to the battery 32. The potential drop across the resistance 41 formed by the space current flow through the tubes 7 and 8 cooperates with the potential drop across resistance 41 in circuit with the battery 33 to control the copper-oxide bridge 9. The current flow through the bridge 9 from the battery 33 lowers the impedance of the bridge across the transmission path. The current flow from the battery 32 through the tubes 7 and 8 and resistance element 41 produces a potential drop across the resistance element 41 which reduces the effect of the battery 33 on the bridge

9. 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 15 as in the case under consideration, then the resistance of the bridge is reduced to increase the shunting action thereof.

A gain increaser circuit 44 is provided for impressing a positive charge on the control condensers 27 and 28 to increase the gain on the transmission path effected by the vario-repeater 6. The gain increaser circuit 44 comprises a filter 45 connected to the input conductors 2 and 3 ahead of a vario-repeater 6. The filter 45 selects a frequency band within the voice frequency range which is centered around a frequency of 1200 cycles. The filter 45 is connected by a transformer 46 to the input circuit of an amplifier 47 of any suitable type. The output circuit of the amplifier 47 is connected by a transformer 48 to the diode portion of a diode-triode 49. The diode-triode 49 comprises control grid 50, cathode 51, an anode 52 and auxiliary anodes 53. A resistance 54 and a condenser 55 are shunted across the secondary winding of transformer 48 to properly terminate the winding and give the transformer the desired frequency characteristic.

The rectifier circuit completed by the diode portion of the diode-triode 49 may be traced from one terminal of the secondary winding of the transformer 48 through the auxiliary anodes 53, cathode 51, resistance element 56 and coupling resistance 57, to the other terminal of the secondary winding of the transformer 48. When a suitable alternating current is impressed on the gain increaser circuit 44, the resistance element 57 shunted by the condenser 58, and the condenser 59 in series with the resistance element 60 impresses a steady or slowly varying negative potential on the control grid 50 of the triode portion of the diode-triode. The output from the triode portion of the diode-triode tube 49 is supplied to a gain increaser relay 61 and a gain rate relay 62. The gain increaser relay 61 comprises a biasing winding 63 and an operating winding 64. The gain rate relay 62 comprises a biasing winding 65 and an operating winding 66. The biasing windings 63 and 65 of the relays 61 and 62 are energized from a battery 67.

A transformer 68 connects the output circuit of the triode portion of the diode-triode tube 49 to the operating coil 64 of the gain increaser relay 61. A condenser 69 is connected across the primary winding of the relay 68 in order to tune the circuit to syllabic frequencies. Preferably, the circuit is tuned to six or eight cycles. A copper-oxide varistor element 70 is connected in the circuit between the operating coil 64 of the gain increaser relay 61 and the secondary winding of the transformer 68 to operate the relay 61 on the rising portion of a syllabic impulse. A second copper-oxide rectifier element 71 is shunted across the secondary winding of the transformer 68 in order to insure that the relay 61 cannot be operated on the falling portion of a syllabic impulse.

The gain increaser relay when operated moves an armature 72 from engagement with a contact member 73 into engagement with a contact member 74. Upon engagement of the armature 72 with the contact member 74, a circuit is completed for impressing a positive charge on the control condensers 27 and 28. Two resistance elements 75 and 76 are connected in circuit with the battery 67 and the drop across the resistance

elements 75 and 76 is employed for charging the control condensers 27 and 28 with positive potential. The circuit for charging the condensers 27 and 28 may be traced from the resistance elements 76 and 75 through contact member 77, armature 78 of the relay 62, resistance element 79, armature 72, contact member 74, resistance element 80, resistance elements 30 and 31 and condenser 27 in shunt with the resistance 29 and condenser 28, resistance 41, battery 33 and ground return to the resistance elements 76 and 75. A battery 85 is connected through a resistance 86 to the contact member 73 for impressing a negative potential on the armature 72. The impressing of a negative charge on the armature 72 prevents the leakage of any positive charge to the contact member 74 from the resistance elements 75 and 76. A resistance element 87 provides a leak for the charge on the condensers 27 and 28. The voltage finally arrived at is controlled by the potential drop across the resistance element 88.

The operating coil 66 of the gain rate relay 62 is connected in series with the primary winding of the transformer 68 in order to be operated in accordance with the output from the triode portion of the diode-triode 49. The plate current of the triode portion decreases as the signals on the transmission line before the vario-repeater 6 increases. If the signals on the transmission path before the vario-repeater 6 increase above a predetermined level, the plate current of the triode of the diode-triode 49 is reduced to such point that the relay 62 is released. Upon release of the relay 62 the armature 78 disengages the contact member 77 and engages contact member 81. This operation of the gain rate relay 62 serves to change the rate of gain increase effected by the gain increaser circuit 44. The condensers 27 and 28 are now charged only by the drop across the resistance element 76 in place of the drop across resistance elements 75 and 76, as formerly.

When signals are received from the transmission path, the filter 45 selects the desired range of voice frequency components, which are amplified by amplifier 47. A peak limiter 83 in the output circuit of amplifier 47 is provided for chopping off extremely high peaks and for limiting the overloading of the tube 49. The output from the amplifier 47 is rectified by the diode portion of the diode-triode 49 to supply negative bias to the control grid of the triode portion of the diode-triode. A frequency of six or eight cycles, due to syllabic modulation of the voice currents is selected in the output circuit of the triode portion of the diode-triode 49 for operating the gain increaser relay 61. Each time the gain increaser relay 61 is operated, it impresses an increment of positive charge on the control condensers 27 and 28. This progressively decreases the negative charge on the control condensers and on the grids 10 and 15 of the tubes 7 and 8 to decrease the impedance of the tubes 7 and 8 and increase the space current flow therethrough. The space current flow through the tubes 7 and 8 in turn decreases the shunt impedance of the copper-oxide bridge 9. If the signals on the transmission line before the vario-repeater are above a predetermined level, the gain control relay 62 is operated to decrease the rate at which the control condensers 27 and 28 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:

5 1. In a gain adjusting circuit, a vario-repeater for controlling the gain on a signal circuit, means comprising a forward-acting gain increaser circuit for governing said vario-repeater under control of syllabic impulse to raise the gain on
10 the signal circuit, and means for insuring control of the vario-repeater by the gain increaser circuit only on the rising portion of a syllabic impulse.

2. In a gain adjusting circuit, a vario-repeater
15 for controlling the gain on a signal circuit, means comprising a forward-acting gain increaser circuit for governing said vario-repeater under control of syllabic impulses to raise the gain on the signal circuit, and means controlled directly according to the signal level on the signal circuit
20 before said vario-repeater for reducing the rate of change in gain increase when the signals are above a predetermined level.

3. In a gain adjusting circuit, a vario-repeater
25 for controlling the gain on a signal circuit, means comprising a forward-acting gain increaser circuit for governing said vario-repeater under control of syllabic impulses to raise the gain on the signal circuit, means for insuring control of the
30 vario-repeater by the gain increaser circuit only on the rising portion of a syllabic impulse, and means controlled according to the signal level on the signal circuit before said vario-repeater for reducing the rate of change in gain increase when the signals are above a predetermined level.
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4. In a gain adjusting circuit, control means connected to a transmission line for governing the energy level of the signals on the line, a relay for operating said control means, a gain increaser circuit connected to said line ahead of the connection of the control means thereto for governing said relay to raise the level of the signals on said line beyond the control means, means on said gain increaser circuit to effect control of
45 the relay by syllabic impulses, and means for insuring control of the relay only on a rising portion of a syllabic impulse.

5. In a gain adjusting circuit, a vario-repeater for governing the energy level of the signals on
50 a signal circuit, means comprising a relay for governing said vario-repeater, a gain increaser circuit connected to said signal circuit ahead of said vario-repeater for governing said relay to raise the gain on the signal circuit, means on said
55 gain increaser circuit to effect control of the relay by syllabic impulses, and means comprising a rectifier element connected in series with the coil of said relay to insure operation of the relay only on the rising portion of a syllabic impulse.

6. In a gain adjusting circuit, a vario-repeater for governing the energy level of the signals on
60 a transmission line, means comprising a relay for governing said vario-repeater, a gain increaser circuit connected to said line ahead of said vario-repeater for governing said relay to raise the gain on the transmission line, means on said gain increaser circuit to effect control of the relay by syllabic impulses, means for insuring control of said relay only on a rising portion of a syllabic impulse,
65 and means comprising a second relay controlled by the syllabic impulses on the gain increaser circuit

for reducing the rate of gain increase when the signals on the line before the vario-repeater are above a predetermined level.

7. In a gain adjusting circuit, a vario-repeater for controlling the gain on a transmission line,
5 means comprising a control condenser for controlling said vario-repeater according to the polarity and strength of the charge on the condenser, a gain decreaser circuit for impressing a charge on said condenser in a direction to decrease the gain on the line when the signals on the line beyond said vario-repeater are above a predetermined upper limit, a gain increaser circuit connected to the line before said vario-repeater for impressing a charge of opposite polarity on said condenser under control of syllabic impulses to raise the gain on the line, means for insuring charging of the condenser by the gain increaser circuit only on the rising portion of a syllabic impulse, and forward-acting means for
10 reducing the rate of charge of the condenser by the gain increaser circuit when the signals are above a predetermined level.
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8. In a gain adjusting circuit, a vario-repeater for controlling the gain on a transmission line,
25 means for controlling said vario-repeater to lower the gain when the energy level of the signals on the line beyond said vario-repeater go above a predetermined upper limit, means comprising a gain increaser circuit connected to the line before said vario-repeater for governing said vario-repeater under control of syllabic impulses to raise the gain on the transmission line, means for insuring control of the vario-repeater by the gain increaser circuit only on the rising portion of a syllabic impulse, and forward-acting means for reducing the rate of change of the gain increase by the gain increaser circuit when the signals are above a predetermined level.
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9. In a gain adjusting circuit, a vario-repeater
40 for controlling the gain on a transmission line, a filter connected to the transmission line at a point before said vario-repeater and tuned to a frequency within the signal frequency range, an amplifier connected to the output of said filter, a
45 peak chopper connected to the output of said amplifier, a rectifier for rectifying the output of said amplifier under control of said peak chopper, a second amplifier having negative bias supplied thereto by said rectifier and having an output
50 varying oppositely to signal variations on the line, the output circuit from said second amplifier being tuned to syllabic frequency, a polarized relay connected by a transformer to the output circuit of said second amplifier, a rectifying element connected in series circuit between said transformer and the polar relay to operate said relay on the rising portion of a syllabic impulse, a rectifying element connected across the coil of said relay to prevent operation of the relay on the decreasing portion of a syllabic impulse, means controlled by said relay for governing said vario-repeater to raise the gain on the transmission line, and a second relay operated by the output from said second amplifier for reducing the rate of change in gain increase when the signals on the line before the vario-repeater are above a predetermined level.
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