

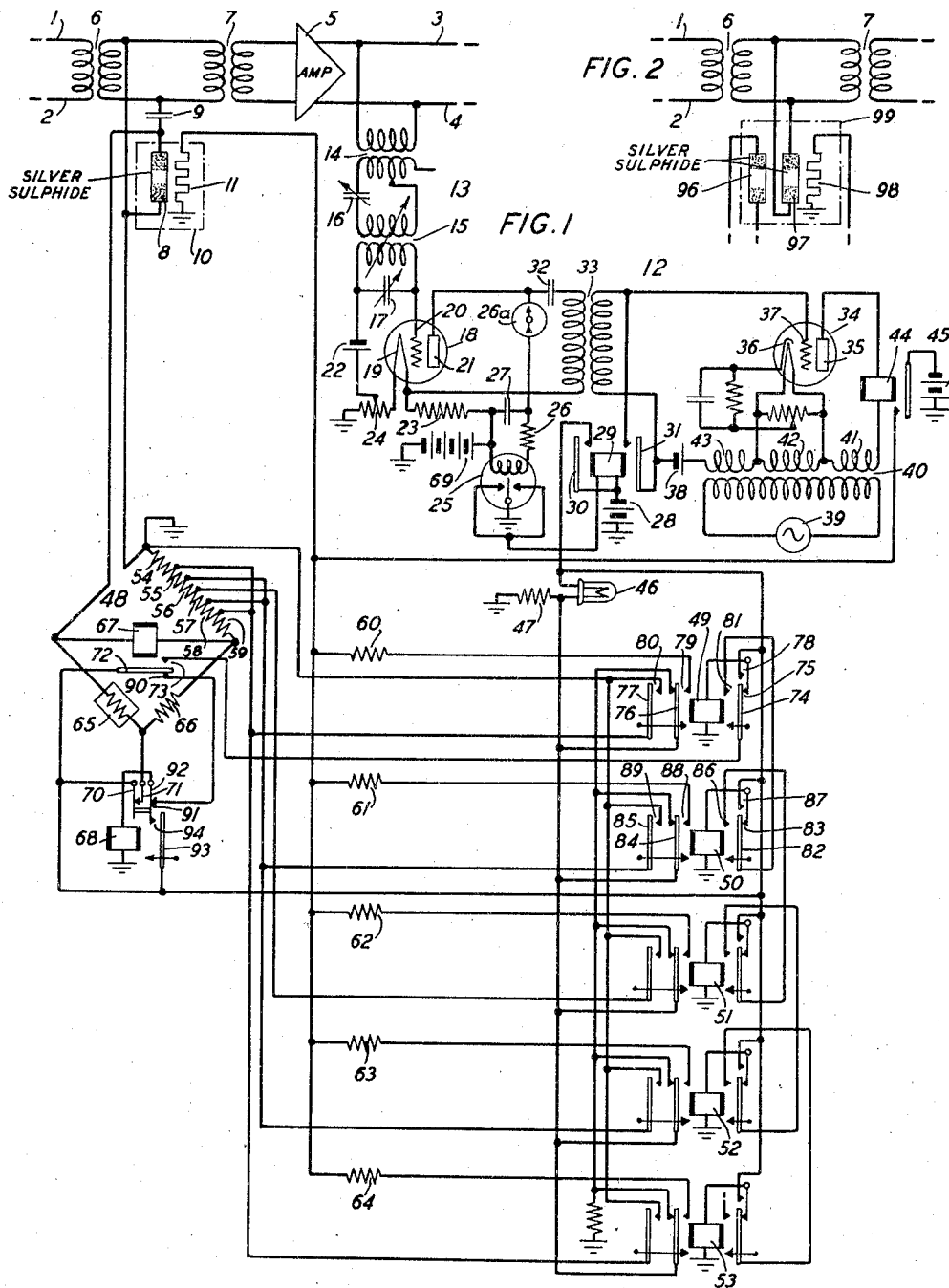
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GAIN CONTROL CIRCUIT

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INVENTORS: L. R. COX  
D. M. TERRY

BY

Wayne B Wells  
ATTORNEY

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## GAIN CONTROL CIRCUIT

Leslie R. Cox, Lyndhurst, N. J., and Donald M. Terry, Brooklyn, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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This invention relates to automatic gain control circuits for transmission lines and particularly to automatic gain control circuits governed by pilot currents.

One object of the invention is to provide a gain control circuit having an element with a high temperature coefficient of resistance in a transmission line that shall control the heating of the element according to the level of the currents on the line in an improved manner to maintain the transmission line attenuation constant.

Another object of the invention is to provide a gain control circuit having a resistance element with a high temperature coefficient of resistance in a transmission line that shall control the heating of the resistance element according to the level of the currents on the transmission line to maintain the line attenuation constant and that shall hold the temperature of the resistance element substantially unchanged in case of abnormal change in level of the currents on the transmission line.

A further object of the invention is to provide a gain control circuit having an element of silver sulphide in an attenuation network connected to a transmission line that shall control the heating of the silver sulphide element according to the level of a pilot current to maintain the line attenuation constant, that shall hold the temperature of the silver sulphide element constant in case of abnormal change in level of the pilot current and that shall return the silver sulphide element to automatic control upon cessation of the abnormal level of the pilot current.

A transmission line such, for example, as an open wire carrier current transmission line, is subjected to attenuation changes by reason of weather changing conditions. The attenuation of a transmission line must be maintained substantially constant to obtain good quality of transmission. The attenuation of a line may be controlled by governing an attenuation network on the line or by governing the amplification at a repeater station.

According to the invention, an attenuation network is connected to a transmission line ahead of an amplifying repeater. One element of the network comprises a resistance element having a high temperature coefficient of resistance. The resistance element is preferably composed of silver sulphide. If so desired, the resistance element may be composed of other similar resistance elements, such, for example, as boron. The temperature of the silver sulphide element is controlled in accordance with the power level of a

pilot current on the transmission line. The transmission line employed to describe the invention is assumed to transmit carrier currents for signal purposes and a pilot current for gain control purposes. A filter which selects the pilot current is connected to the transmission line beyond the amplifying repeater. The filter is connected to a space discharge detector tube which is compensated for changes in the power current supplied to the plate circuit. The alternating current component in the output of the detector tube is supplied to a gas-filled trigger tube which in turn controls a relay to govern a heater. The heater governs the heating of the silver sulphide element in the attenuation network to maintain the line attenuation substantially constant.

The direct current component in the output circuit of the detector tube operates a galvanometer relay which in turn operates a control relay. The galvanometer relay is set to operate the control relay only in case of abnormal level conditions on the transmission line. Thus, the control relay is operated in case of a break or a short-circuit on the transmission line. The control relay prevents operation of the gas-filled tube by short-circuiting the input circuit thereof and controls a bridge circuit to insure that no change in the heating of the silver sulphide element takes place during abnormal level conditions on the transmission line.

The bridge circuit which is governed by the control relay has one arm thereof formed by the silver sulphide element in the attenuation network. If so desired, a separate element of silver sulphide may be provided in the bridge arm which is subjected to the same heating conditions as the silver sulphide element in the attenuation network. Another element of silver sulphide similar to the silver sulphide element in the attenuation network is heated to room temperature for compensating the bridge for the room temperature of the silver sulphide element in the attenuation network.

If the bridge circuit is unbalanced when energized by the control relay, a galvanometer relay, or suitable polarized relay, is energized to operate one or a number of consecutively operated relays. The relays operated by the bridge galvanometer relay complete an energizing circuit for the heating coil of the silver sulphide element in the attenuation network so as to maintain the temperature of the silver sulphide element substantially unchanged. The relays, operated in sequence by the galvanometer relay, also adjust resistance in the bridge circuit to rebalance the

bridge circuit. If the bridge circuit is not re-balanced upon operation of the first relay, then the second relay is operated and so on until a balance of the bridge circuit is effected.

5 The heating of the silver sulphide element in the attenuation network is controlled by the bridge circuit as long as the abnormal level condition of the pilot current exists. When the abnormal level condition of the pilot current ceases, 10 the control relay is released to permit automatic control of the heating coil for the silver sulphide element in the attenuation network under control of the gas-filled trigger tube.

In the accompanying drawing Fig. 1 is a diagrammatic view of a gain control circuit constructed in accordance with the invention.

Fig. 2 is a diagrammatic view showing a separate resistance element for controlling the bridge circuit shown in Fig. 1.

20 Referring to Fig. 1 of the drawing, a transmission line comprising input conductors 1 and 2 and output conductors 3 and 4 is provided with a repeater amplifier 5 of any suitable type and preferably of the space discharge type. The input conductors 1 and 2 in the transmission line are connected to the amplifier 5 by means 25 of transformers 6 and 7. An attenuation network comprising a resistance element 8 and a condenser 9 is connected across the line between the secondary winding of the transformer 6 and the primary winding of the transformer 7. The resistance element 8 is shown as being composed of silver sulphide and should have a high temperature coefficient of resistance. The silver sulphide element 8 may be included in a network 35 of the type disclosed in the application of R. W. Chesnut, Serial No. 157,497 filed August 5, 1937, if so desired. The attenuation network serves to control the attenuation of the transmission line so as to maintain the line attenuation constant irrespective of weather conditions. The silver sulphide element 8 is placed in an oven 10 with a heater element 11.

45 The heater 11 is governed by gain control circuits 12 in accordance with the level of a pilot current on the transmission line beyond the repeater amplifier 5. The transmission line in the system employed to describe the invention is assumed to carry not only signal currents by means of carrier currents but also a pilot current for gain control purposes. A filter 13 comprising transformers 14 and 15 and adjustable condensers 16 and 17 is connected across the transmission line beyond the amplifier 5. The filter 13 selects the pilot current for controlling the circuits 12.

A detector space-discharge device 18 is connected to the filter 13. The device 18 comprises a cathode 19, a grid 20 and an anode 21. The grid 20 is biased by means of a battery 22. An anode battery 23 for the device 18 is provided in circuit with a resistance 23 in the anode circuit and an adjustable resistance 24 in the grid circuit. The potential drop across the resistance 24 in the grid circuit of the device 18 serves to compensate the grid circuit for any change of potential in the anode circuit. The direct current output circuit of the device 18 which is connected across the resistance 23 includes the coil of a galvanometer relay 25, a resistance 26 and a volume indicator 26a. A condenser 27 serves to filter out an alternating current component having a frequency equal to the differ- 75

ence between the pilot current and the carrier currents.

The galvanometer relay 25 is set to be operated only in case of abnormal energy level condition of the pilot current on the transmission 5 line. For example, the galvanometer relay may only operate in case of an open circuit condition or a short circuit condition. The relay 25 when operated either by an open circuit or a short circuit condition completes a circuit from a 10 battery 28 for operating a control relay 29. The control relay 29 is provided with two switch members 30 and 31. The functions performed thereby will be set forth hereinafter.

A condenser 32 and the primary winding of a transformer 33 are connected to the cathode and anode of the device 18, for selecting the alternating current component in the output circuit of the detector tube 18. The alternating current component in the output circuit of the detector tube 18 is selected for controlling an energization circuit for the heater 11. The secondary winding of the transformer 33 is connected to the input circuit of a gas-filled space discharge device 34. The device 34, which operates as a 25 marginal device comprises an anode 35, a cathode 36 and a grid 37. A biasing battery 38 is provided in the grid circuit of the device 34. A source of 60 cycle 110 volt alternating current 39 is connected to a transformer 40, which supplies alternating potential to the anode 35 by means of a secondary winding 41. A secondary winding 42 is provided for heating the cathode 36. A third secondary winding 43 is provided to compensate the grid circuit for any change in potential supplied to the anode circuit. A relay 44 in the anode circuit of the device 34 is provided for completing the energizing circuit for the heater 11 from a battery 45. Thus upon 40 ignition or triggering off of the device 34 an energizing circuit from the battery 45 is completed for heating the element of silver sulphide 8. The switch member 31 of the control relay 29 completes a circuit across the grid circuit of the device 34 so that upon operation of the galvanometer relay 25 and the control relay 29, 45 the grid circuit of the device 34 is blocked. The blocking of the grid circuit of the device 34 prevents any automatic control of silver sulphide element 8 according to the energy level of the pilot current on the transmission line.

In the gain control circuits 12 thus far described, a raise in the energy level of the pilot current on the transmission line will supply current through the filter 13, the detector tube 18 55 and the transformer 33 for producing a discharge in the device 34. The device 34 when discharging operates the relay 44 to complete the energizing circuit for the heater 11. The heater 11 reduces the resistance of the silver sulphide element 8 which in turn increases the attenuation on the transmission line. The attenuation of the transmission line is lowered until the energy level of the pilot current is reduced below a level which will insure extinguishing the device 34. The device 34 when 65 extinguished releases the relay 44 to prevent further energization of the heater 11. The silver sulphide element 8 is then slowly cooled until the attenuation on the line is lowered to a point that the energy level of the pilot current is raised to again operate the gas-filled space discharge device 34. The above cycle of operations is again repeated.

In case the galvanometer relay 25 is operated 75

by reason of abnormal power level conditions on the transmission line, the control relay 29 is operated to complete a circuit from the battery 28 through the switch member 30, a ballast lamp 46 and a resistance element 47. The battery 28 provides potential for operating a bridge 48 and for operating relays 49, 50, 51, 52 and 53. The relays 49 to 53, inclusive, are slow to operate and serve to complete an auxiliary energizing circuit for the heater 11 from the steady potential obtained across the resistance 47. The relays 49 to 53, inclusive, also control resistance elements 54, 55, 56, 57, 58 and 59 in one arm of the bridge circuit 48 for rebalancing the bridge. The auxiliary energizing circuit for the heater 11, which is completed through one or more of the resistance elements 60 to 64, inclusive, serves to maintain the temperature of the silver sulphide element 8 unchanged during abnormal power level conditions on the transmission line.

The bridge circuit 48 has one arm thereof formed by the silver sulphide element 8 and another arm formed by the resistance elements 54 to 59, inclusive. A resistance element 65, which is similar to the resistance element 8, forms another arm of a bridge circuit. The resistance element 65 is subjected to room temperatures for compensating the bridge operation for changes in room temperature during abnormal power level conditions on the transmission line. The fourth arm of the bridge circuit is formed by a resistance element 66. A galvanometer relay or any other suitable polarized relay 67 is connected across two opposite vertices of the bridge 48 for controlling the operation of the relays 49 to 53, inclusive. The relay 67 also controls a relay 68 which is slow to operate.

Assuming abnormal power level conditions on the transmission line, the galvanometer relay 25 and control relay 29 are energized to complete the circuit from the battery 28 through the ballast lamp 46 and the resistance element 47. At this time a circuit is completed from battery 28 through a switch member 70 controlled by the relay 68 and a contact member 71 to a vertex of the bridge 48. The opposite vertex of the bridge is grounded to complete an energizing circuit for operating the bridge relay 67. The bridge relay 67 upon operation completes a circuit for operating the relay 49. The circuit for operating the relay 49 may be traced from battery 28 through switch member 30, switch member 72, operated by the relay 67, contact member 73, switch member 74 operated by the relay 49, contact member 75 and coil of the relay 49 to ground. The relay 49 is energized to operate switch members 74, 76 and 77. The switch member 74 upon operation prepares a circuit for operating the relay 50. A holding circuit for the relay 49 is completed by a switch member 78 engaging the switch member carrying the contact member 75. The holding circuit for the relay 49 extends from the battery 28, switch member 30 and coil of relay 49 to ground. The switch member 76 when operated by the relay 49 completes an auxiliary energizing circuit for the heater 11. The circuit through the heater 11 may be traced from ground through the heater 11, resistance element 60, contact member 79, switch member 76 and resistance element 47 to ground. The switch member 77 upon operation of the relay 49 engages a contact member 80 for short-circuiting the resistance member 54 to rebalance the bridge circuit.

If the bridge circuit is not rebalanced and the

relay 67 released by short-circuiting of the resistance element 54, then the relay 50 is operated. The circuit for operating the relay 50 may be traced from one terminal of the battery 28 through switch member 30, switch member 72, contact member 73, switch member 74, contact member 81, switch member 82 controlled by the relay 50, contact member 83 and coil of the relay 50 to ground. The relay 50 upon energization operates the switch members 82, 84 and 85. The switch member 82 disengages the contact member 83 and engages a contact member 86 for preparing a circuit to operate the relay 51. A holding circuit for the relay 50 is established by a contact member 87 engaging the switch member carrying the contact member 83. The switch member 84 engages a contact member 88 for completing a circuit through the resistance element 61 in parallel to the resistance element 60 to energize the heater 11. The switch member 85 operated by the relay 50 engages a contact member 89 to short-circuit the resistance element 55 in the bridge circuit. The resistance element 55 is short-circuited to rebalance the bridge circuit.

If the bridge circuit is not rebalanced at this time by reason of the short-circuiting of the resistance elements 54 and 55, then the relay 51 is operated in the manner above-described as to the relays 49 and 50. The relay 51 connects the resistance element 62 in parallel to the resistance elements 61 and 60 in the energizing circuit for the heater 11. The relay 51 also short-circuits the resistance element 56. The relays 52 and 53 control the resistance elements 63 and 64 in the auxiliary heating circuit for the heater 11 and also control the resistance elements 57 and 58 for rebalancing the bridge circuit. The circuits completed through the resistance elements 60, 61, 62, 63 and 64 serve to complete an auxiliary energizing circuit for the heater 11 so as to maintain the silver sulphide element 8 at a constant temperature.

When the bridge 48 is rebalanced upon selective operation of the relays 49 to 53, inclusive, the polar relay 67 is released. Upon release of the polar relay 67, a circuit is completed for energizing the relay 68. The circuit for energizing the slow-to-operate relay 68 may be traced from one terminal of the battery 28 through switch member 30, switch member 72 controlled by the relay 67, contact member 90, contact member 91, switch member 92, and coil of the relay 68 to ground. The relay 68, when energized, operates a switch member 93 for engaging contact member 94 to complete a holding circuit for the relay. The contact member 91 is separated from the switch member 92 to prevent any change in the number of the relays 49 to 53, inclusive, which have been operated. The contact member 71 is disengaged from the switch member 70 to deenergize the bridge circuit. Thus, no further control of the relays 49 to 53 can be effected by the bridge 48 during the time the abnormal power level condition obtains on the transmission line.

When the power level of the pilot current on the transmission line is returned to normal level, the galvanometer relay 25 and the control relay 29 are released. The release of the relay 29 breaks the holding circuit for any of the operated relays 49 to 53, inclusive, and the holding circuit for the relay 68. The release of the operated relays 49 to 53, inclusive, insures deenergizing of the auxiliary energizing circuit for the heater 11. Furthermore, the switch member 31 opens the

blocking circuit for the gas-filled space discharge device 34 to permit automatic control of the heater 11 in accordance with the power level of the pilot current on the transmission line.

5 The temperature of the silver sulphide element 2 is influenced by current in the heater 11 and by existing room temperature. The silver sulphide element 65 in the bridge circuit serves to compensate the bridge operation for any change  
10 in the room temperature. If an abnormal pilot level occurs when the room temperature is high, then less heating current would need to be supplied to the heater than when the room temperature is low. During automatic operation of the  
15 gain control circuits, a change in the resistance of the silver sulphide element 8 which is effected by reason of room temperature changes will be taken care of by the automatic gain control circuits 12.

20 Referring to Fig. 2 of the drawing, a modification of the invention is shown wherein a separate silver sulphide element 96 is provided for controlling the operation of the bridge circuit 48. The terminals of the resistance element 96 are  
25 connected to the bridge 48 in the same manner as the terminals of the element 8 shown in Fig. 1 of the drawing are connected to the bridge 48. The silver sulphide element 97 in Fig. 2 of the drawing corresponds to the silver sulphide ele-  
30 ment 8 in Fig. 1 of the drawing. The heater 98 corresponds to the heater 11. The heater 11 and the two silver sulphide elements 96 and 97 are enclosed in the same oven 99. The condenser 9 shown in the circuit of Fig. 1 of the drawing may  
35 be omitted from the circuit shown in Fig. 2 of the drawing. The circuit shown in Fig. 2 of the drawing operates in exactly the same manner as the circuit shown in Fig. 1 of the drawing. A detailed description thereof is deemed unnecessary.

40 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.

45 What is claimed is:

1. In combination, a signal transmission line, an attenuation network on said transmission line comprising a resistance element having a high  
50 temperature coefficient of resistance, control means governed according to the energy level of the currents on the line for heating said resistance element to maintain the transmission line attenuation substantially constant, and means operative in case of an abnormal change  
55 in the energy level of the currents on the line for preventing operation of said control means and for independently heating said element to prevent change in the resistance thereof.

2. A transmission line carrying signal currents and a pilot current, an attenuation network on  
60 said transmission line comprising a resistance element having a high temperature coefficient of resistance, control means governed by the energy level of said pilot current for heating said resistance element to maintain the transmission  
65 line attenuation substantially constant, and means operative in case of an abnormal change in the energy level of the pilot current for preventing operation of said control means and for  
70 independently heating said element to hold the temperature of said resistance element substantially constant.

3. In combination, a signal transmission line, an attenuation network on said transmission line  
75 comprising an element of silver sulphide, control

means governed according to the level of the currents on the line for heating said element of silver sulphide to maintain the transmission line attenuation substantially constant, and means  
5 operative in case of an abnormal change in the level of the currents on the line for preventing operation of said control means, for independently heating said element to hold the temperature thereof constant during the abnormal level condition and for returning the control means to  
10 operative condition when the abnormal level condition ceases.

4. In combination, a signal transmission line, an attenuation network on said transmission line comprising an element of silver sulphide,  
15 control means governed by a pilot current on said line for heating said element of silver sulphide to maintain the line attenuation constant, auxiliary means operative in case of an abnormal change in the level of the pilot current for pre-  
20 venting operation of said control means and means operated by said auxiliary means for heating said element to hold the temperature thereof constant during the abnormal condition of the pilot current.

5. In combination, a signal transmission line, an attenuation network on said transmission line comprising an element having a high temperature coefficient of resistance, means for heating  
25 said element according to the level of the currents on said line to maintain the line attenuation constant, a bridge circuit having one arm thereof varying in resistance according to the resistance variations of said element, means operative  
30 in case of an abnormal change in level of the currents on the line for preventing operation of said first-mentioned means and for energizing said bridge circuit, and means operated by said bridge circuit for holding the temperature of said element substantially unchanged.

6. In combination, a signal transmission line, an attenuation network on said transmission line comprising an element of silver sulphide, control  
35 means for heating said element of silver sulphide according to the level of the currents on said line to maintain the line attenuation constant, a bridge circuit having one arm thereof varying in resistance according to the resistance variations of said element, means for compensating said  
40 bridge for the room temperature of said element, means operative in case of abnormal change in level of the currents on the line for preventing operation of said control means and for energizing said bridge, and means operated by said  
45 bridge for holding the temperature of said element substantially unchanged.

7. In combination, a signal transmission line, an attenuation network on said transmission line comprising an element having a high temperature coefficient of resistance, control means for  
50 heating said element according to the level of the currents on the line to maintain the line attenuation constant, a bridge circuit having one arm thereof formed by said element, another arm of said bridge formed by a similar element to compensate for room temperatures, means  
55 operative in case of an abnormal change in level of the currents on the line for preventing operation of said control means and for energizing said bridge, means operated by said bridge for holding the temperature of said first-mentioned element substantially unchanged, and means  
60 operative upon return of the line currents to normal level for deenergizing said bridge and for rendering said control means operative.

8. In combination, a signal transmission line, 75

an attenuation network on said transmission line comprising an element of silver sulphide, a coil for heating said element of silver sulphide, control means governed according to the level of the currents on the transmission line for controlling said coil to heat the element of silver sulphide and maintain the line attenuation constant, a bridge circuit having one arm thereof varying in resistance according to the resistance value of said element of silver sulphide, a bridge relay connected across two opposite vertices of said bridge, relay means operative upon an abnormal change in level of the currents on said line for connecting a source of potential across the other two vertices of said bridge circuit and for preventing operation of said control means, and means operated by said bridge relay upon operation of said relay means and unbalancing of the bridge for completing a circuit through said heating coil to maintain the temperature of said element of silver sulphide substantially constant.

9. In combination, a signal transmission line, an attenuation network on said transmission line comprising an element having a high temperature coefficient of resistance, means for heating said element according to the level of the currents on said line to maintain the line attenuation constant, a bridge circuit having one arm thereof varying in resistance according to the resistance value of said element, another arm of said bridge being formed by a second resistance element having characteristics similar to said first-mentioned element to compensate the bridge operation for room temperature, relay means operative upon an abnormal level change of the currents on said line for preventing operation of said heating means and for energizing said bridge circuit, and means comprising a set of relays consecutively operated by said bridge for holding the temperature of said first-mentioned element constant for rebalancing said bridge circuit and for holding the operated relays in operative position, said relay means upon return of the currents on the line to normal level serving to render said heating means for the first-mentioned element operative and to deenergize the bridge and the relays controlled thereby.

10. In combination, a transmission line carrying signal currents and a pilot current, a network comprising an element of silver sulphide for controlling the line attenuation, a filter connected to the line for selecting the pilot current, a detector tube connected to said filter, control means for heating said silver sulphide element under control of the alternating current output from said tube to maintain the line attenuation constant, and means controlled by the direct current output from said tube in case of abnormal change in level of the pilot current for preventing

operation of said control means and for maintaining the temperature of said silver sulphide element constant.

11. In combination a transmission line carrying signal currents and a pilot current, a network comprising an element of silver sulphide having a high temperature coefficient of resistance, a filter connected to the line for selecting the pilot current, a detector tube connected to said filter, a gas-filled tube controlled by the alternating current component in the output of said detector tube, means comprising a heating coil controlled by said gas-filled tube for controlling said element to maintain the line attenuation constant, and means controlled by the direct current output from said detector tube in case of abnormal change in level of the pilot current for preventing operation of said gas-filled tube and for maintaining the temperature of said silver sulphide element constant.

12. A transmission line carrying signal currents and a pilot current, a network comprising a resistance element having a high temperature coefficient of resistance for controlling the line attenuation, means comprising a filter for selecting said pilot current, a detector tube controlled by the output from said filter, a heater coil for said resistance element, control means for heating said coil according to the alternating current component in the output of said detector tube, relay means controlled by the direct current output from said detector tube for preventing operating of said control means in case of abnormal change in the level of the pilot current, and means operated by said relay means for maintaining the temperature of said resistance element substantially unchanged during an abnormal level change of the pilot current.

13. A transmission line carrying signal currents and a pilot current, a repeater on said line, a network comprising a resistance element having a high temperature coefficient of resistance for controlling said repeater, means comprising a filter for selecting said pilot current from the line beyond said repeater, a detector tube controlled by the output from said filter, a heater coil for said resistance element, means comprising a gas-filled space discharge device for heating said coil according to the alternating current component in the output of said detector tube, relay means controlled by the direct current output from said detector tube for preventing operation of said space discharge device in case of abnormal change in the level of the pilot current, and means operated by said relay means for maintaining the temperature of said resistance element substantially unchanged during an abnormal level change of the pilot current.

LESLIE R. COX.  
DONALD M. TERRY.