

July 6, 1937.

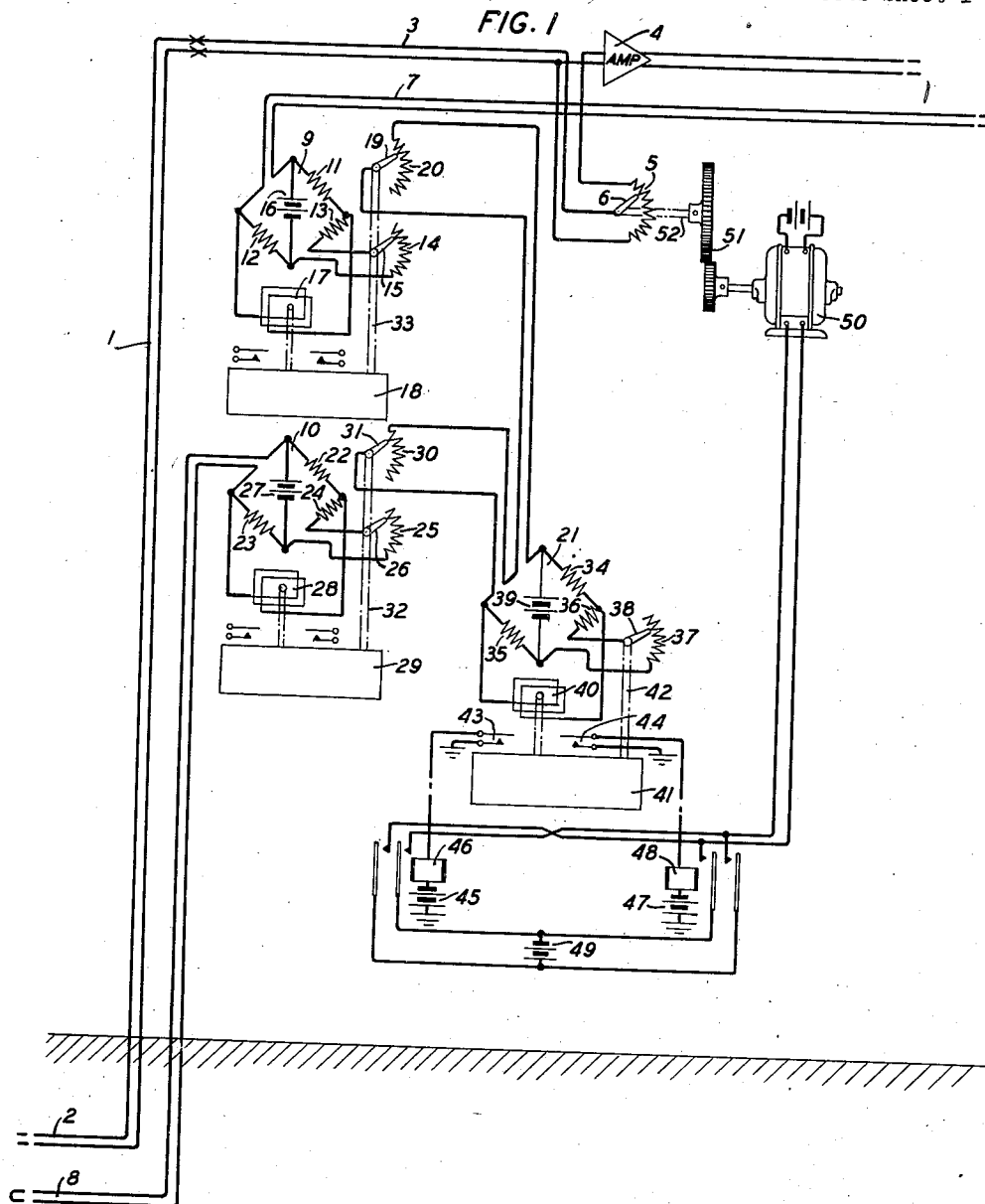
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2,086,106

CONTROL CIRCUITS

Filed March 19, 1936

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 2

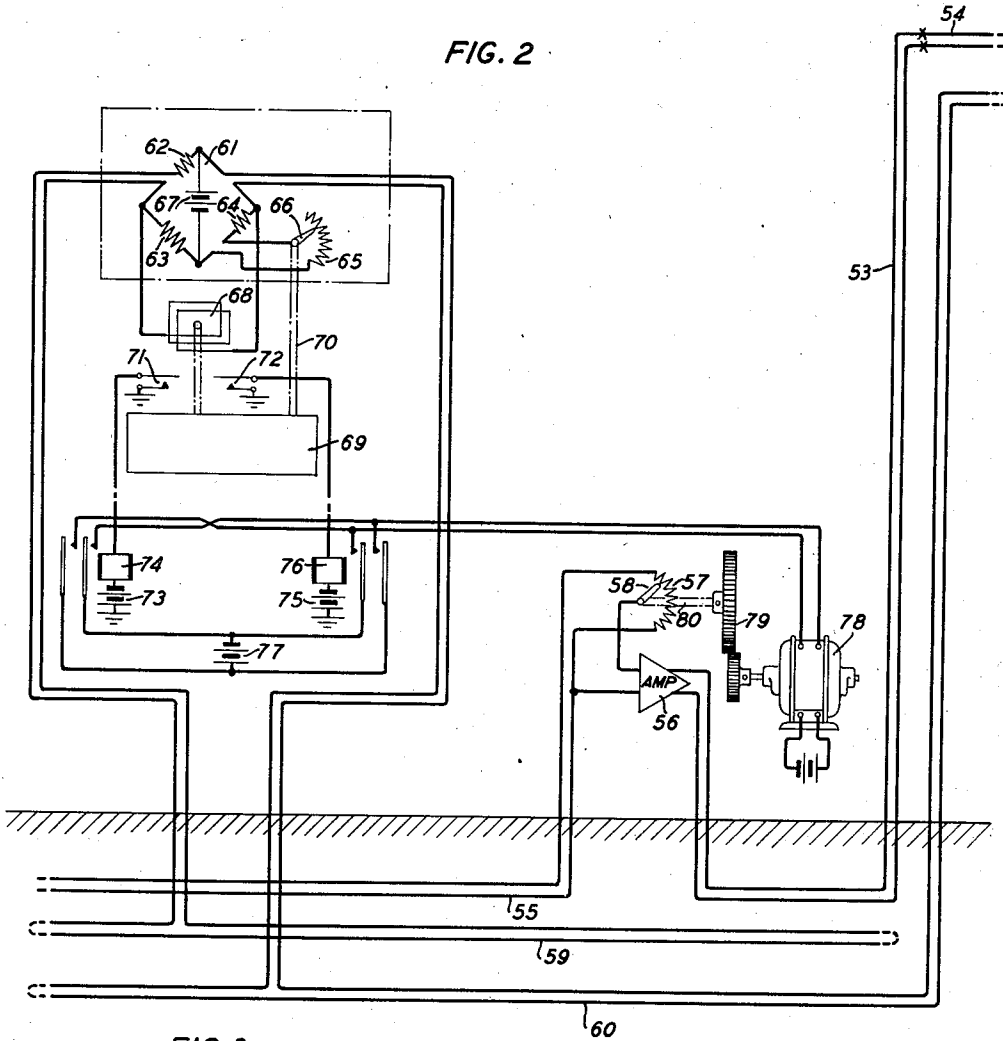
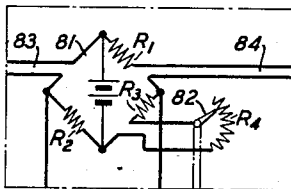


FIG.3



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CONTROL CIRCUITS

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Application March 19, 1936, Serial No. 69,659

17 Claims. (Cl. 178—44)

This invention relates to control circuits for signal transmission lines, and particularly to attenuation control circuits for signal transmission lines.

5 One object of the invention is to provide a signal transmission line comprising a number of sections with attenuation control circuits that shall differentiate for the characteristics of the different line sections.

10 Another object of the invention is to vary the gain of an amplifier in accordance with the temperature conditions of different parts of an apparatus.

15 Another object of the invention is to provide a signal transmission line divided into sections and having attenuation control circuits that shall differentiate for the attenuation temperature coefficients of the different transmission line sections.

20 Another object of the invention is to provide a transmission line divided into a number of different sections with attenuation control circuits that shall govern the line attenuation in accordance with the resistance variations of a number of pilot lines associated with the line sections.

25 A further object of the invention is to provide a transmission line divided into a number of sections and having pilot lines associated with the line sections that shall govern the transmission line attenuation according to the resistance variations of the pilot lines while differentiating for the lengths of the line sections and for the different attenuation temperature coefficients of the line sections.

30 The attenuation of a signal transmission line varies with the changes in the weather and particularly varies with changes in temperature. A signal transmission line is frequently composed of sections which are of different lengths and which are subjected to different temperature varying conditions. A portion of the signal transmission line may be a cable located underground and another portion of the line may be an aerial cable.

35 If a signal transmission line has a section located underground and a section located above ground, it may be desirable to control the transmission line attenuation in accordance with the attenuation variation caused by the temperature variations in either or both line sections. Furthermore, it may be desirable to control the attenuation of a signal transmission line according to the attenuation variation caused by temperature variations in a line section located some distance from the repeater or control station.

According to the present invention the attenuation of a signal transmission line, which is divided into sections subjected to different temperature variations, may be controlled or maintained constant by means of a plurality of pilot lines controlling a Wheatstone bridge regulator. The attenuation of a signal transmission line may also be controlled according to the temperature variations of a section located a distance from the control station by means of a plurality of pilot lines controlling a Wheatstone bridge regulator.

10 In one form of the invention a signal transmission line having an underground section and an above ground section is provided with two pilot lines respectively associated with the two transmission line sections. The two line sections may be of different lengths and the attenuation temperature coefficients of the two sections may be different. The attenuation, temperature coefficient may be defined as the decibels attenuation change in a line per mile per degree Fahrenheit. The two pilot lines respectively form an arm in two auxiliary bridge circuits. The bridge circuits are operated in accordance with the resistance variations in the pilot lines. Each bridge circuit operates a galvanometer to control a galvanometer control mechanism of the type disclosed in the application of Ira G. Wilson, Serial No. 69,658, filed March 19, 1936, or in the patent to J. A. Coy et al., 2,017,654 dated October 15, 1935. The two galvanometer control mechanisms not only balance the auxiliary bridge circuits but each controls a resistance in one arm of a main bridge circuit. The two resistance elements in the arm of the main bridge circuit which are controlled by the two galvanometer control mechanisms have values respectively determined according to the lengths and attenuation temperature coefficients of the two transmission line sections. The main bridge circuit operates a galvanometer control mechanism which, in turn, governs the operation of a motor to maintain the transmission line attenuation constant.

15 In a modification of the invention, the attenuation of a transmission line having a section located underground and a section located above ground is controlled solely in accordance with the temperature variations of the section located above ground. The section located above ground is assumed to be some distance from the repeater station or the control station. Two pilot lines are provided. One pilot line is associated with the underground section and the other pilot line is associated with both the underground section

and the section above ground. Two pilot lines form resistance elements in two adjacent arms of a bridge circuit. The arm including the pilot line associated only with the underground section has an additional resistance element to balance the portion of the other pilot line which is associated with the above ground section. In a bridge so formed it is apparent the bridge will be operated solely in accordance with the temperature variations of the section of the transmission line located above ground. The two pilot lines connected to adjacent bridge arms take care of the differences in lengths of the two transmission line sections and the differences in attenuation temperature coefficients of the two transmission line sections. The bridge circuit operates a galvanometer control mechanism to govern the transmission line attenuation solely in accordance with the temperature variations of the line section located above ground.

In another modification of the invention, a transmission line having a section located below ground and a section located above ground is controlled by two pilot lines and a single bridge circuit to maintain the transmission line attenuation constant. One of the pilot lines is associated with the underground section transmission line and the other pilot line is associated with the above ground section of the transmission line. The two pilot lines are respectively inserted in adjacent arms of the bridge circuit. The bridge arms in the present modification do not have arms of equal resistance as in the case of the bridge circuits employed in the control circuits above-mentioned. Each of the arms including a pilot line includes resistance elements for balancing such arms with the other two arms of the bridge circuit. The resistance elements included in the arms of the bridge containing the pilot lines and the resistance elements included in the arms not including pilot lines are determined so that a variation in the resistance of either pilot line will effect operation of the galvanometer mechanism connected to the bridge circuit in the same direction. The resistance values of the fixed resistances of the bridge circuit are so determined that the bridge is operated by both pilot lines in case of temperature variations in the underground section and is operated solely by the pilot line associated with the underground and the aerial section in case of the temperature variation in the line section located above ground. The bridge circuit operates a galvanometer control mechanism of the type above mentioned for maintaining the attenuation of the transmission line constant.

In the accompanying drawings,

Fig. 1 is a diagrammatic view of attenuation control circuits constructed in accordance with the invention;

Fig. 2 is a diagrammatic view of a modified control circuit wherein the line attenuation is controlled in accordance with the temperature variations of one section thereof, and

Fig. 3 is a diagrammatic view of a modification of the control circuit shown in Fig. 1 of the drawings.

Referring to Fig. 1 of the drawings a transmission line 1 is shown having an underground section 2 and a section 3 located above ground. A suitable amplifier 4 is shown in the above ground section 3 of the transmission line and a potentiometer 5 having a control arm 6 is shown in the above ground section 3 adjacent to the

amplifier 4. A pilot line 7 is shown associated with the above ground section 3 of the transmission line and is subjected to the same temperature variations as the line section 3. A pilot line 8 is shown associated with the underground section 2 of the transmission line and is subjected to the same temperature variations as the underground section 2 of the transmission line.

The pilot line 7 forms one arm of an auxiliary bridge circuit 9 and the pilot line 8 forms one arm of an auxiliary bridge circuit 10. The bridge circuit 9 comprises fixed resistance elements 11, 12 and 13 and a resistance element 14 under control of an arm 15 for balancing the bridge circuit. A battery 16 is connected across two vertices of the bridge 9 and a galvanometer 17 is connected across the other two vertices of the bridge 9. The galvanometer 17 operates galvanometer control mechanism 18 of the type disclosed in the above mentioned application of I. G. Wilson, Serial No. 69,658. The galvanometer control mechanism not only operates the arm 15 to control the resistance 14 and balance the bridge circuit 9, but also controls an arm 19 for varying the value of a resistance element 20. The resistance element 20 is included in one arm of a main bridge circuit 21.

The auxiliary bridge circuit 10 comprises three fixed resistance elements 22, 23 and 24 and a resistance element 25 which is controlled by an arm 26. The resistance 25 is controlled by the arm 26 to balance the bridge 10. A battery 27 is connected across two vertices of the bridge and a galvanometer 28 is connected across the other two vertices of the bridge. The galvanometer 28 operates galvanometer control mechanism 29 of the type shown in the above-mentioned application of I. G. Wilson, Serial No. 69,658 for not only controlling the switch arm 26 and the resistance 25, but also for controlling a resistance 30 by a switch arm 31. The resistance 30 is included in the arm of the main bridge circuit 21 with the resistance 20 which is controlled by the bridge 9 and the galvanometer 17. The two switch arms 26 and 31 are mounted on a shaft 32 which is rotated by the galvanometer control mechanism 29 according to the unbalancing of the bridge 10 by resistance variations in the pilot line 8. The galvanometer control mechanism 18 operates a similar shaft 33 for controlling the switch arms 15 and 19 according to the operation of the bridge 9 by resistance variations in the pilot line 7.

The main bridge circuit 21 not only includes the resistance elements 20 and 30 but includes fixed resistance elements 34, 35, 36 and a variable resistance element 37 which is controlled by a switch arm 38. The resistance element 37 is controlled by the switch arm 38 to balance the bridge circuit 21. The resistance element 20 has its value determined according to the length of the above ground line section 3 and the attenuation temperature coefficient of the section 3 of the transmission line. The resistance 30 has its value determined according to the length of the underground line section 2 and the attenuation temperature coefficient of the underground section 2 of the transmission line. By having the values of resistance elements 20 and 30 determined according to the lengths and attenuation temperature coefficients of the transmission line sections it is possible to control the main bridge circuit 21 by the two pilot lines and differentiate

for the effect of temperature variations in the different transmission line sections.

A battery 39 is connected across two vertices of the bridge 21 and a galvanometer 40 is connected across the other two vertices of the main bridge circuit. The galvanometer 40 operates galvanometer control mechanism 41 of the type disclosed in the above-mentioned application of I. G. Wilson Serial No. 69,658. The galvanometer control mechanism 41 not only operates the switch arm 38 by means of a shaft 42 for rebalancing the bridge circuit 21, but controls two switches 43 and 44. Upon operation of the switch 43 a circuit is completed from a battery 45 for operating a relay 46. Upon operation of the switch 44 a circuit is completed from the battery 47 for operating a relay 48. Upon operation of the relay 46 a circuit is completed from a battery 49 for operating a motor 50 in one direction. Upon operation of the relay 48 a circuit is completed from the battery 49 for operating the motor 50 in an opposite direction. The motor 40 is connected by gearing 51 and a shaft 52 to the switch arm 6 of the potentiometer 5.

If a change in temperature takes place in the underground section 2 of the transmission line or in the above ground section 3 of the transmission line, a like temperature change takes place in the pilot line 8, or in the pilot line 7. The pilot lines effect operation of the auxiliary bridge circuits 9 and 10. The bridge circuits 9 and 10 by means of the galvanometer control mechanisms 18 and 29 not only rebalance the bridge circuits, but also adjust the values of the resistance elements 20 and 30 included in one arm of the main bridge circuit 21. The two resistance elements 20 and 30, as before set forth, differentiate for the difference in lengths of the two transmission line sections and the difference in the attenuation temperature coefficients of the sections of the transmission line. The main bridge circuit 21 effects operation of the galvanometer control mechanism 41 which not only rebalances the bridge circuit 21 by means of the resistance element 37, but also controls the operation of the motor 50. The motor 50 serves to operate the switch arm 6 and adjust the potentiometer 5 to maintain the transmission line attenuation substantially constant.

Referring to Fig. 2 of the drawings, a transmission line 53 is shown having an above ground section 54 and an underground section 55. An amplifier 56 of any suitable type is positioned in the below ground section 55 of the transmission line and a potentiometer 57 having a control arm 58 is positioned in the section 55 adjacent to the amplifier 56. A pilot line 59 which is associated with the underground section 55 of the transmission line, is subjected to the same temperature variations as the section 55. A pilot line 60 is associated not only with the underground section 55 but also with the above ground section 54 of the transmission line. The two pilot lines 59 and 60 are inserted in two adjacent arms of a bridge circuit 61. A resistance element 62 is included in the bridge arm containing the pilot line 59 to balance that portion of the pilot line 60 which is associated with the above ground section 54 of the transmission line. The bridge circuit 61 also includes fixed resistance elements 63 and 64 and an adjustable resistance element 65 which is controlled by a switch arm 66 to rebalance the bridge. A battery 67 is connected across two vertices of the bridge and a galvanometer 68 is connected across the other two

vertices of the bridge. The arms of the bridge are so balanced that a variation in the resistance of the pilot line 59 and a variation in the resistance of that portion of the pilot line 60 which is associated with the underground section 55 of the transmission line will have no effect in operating the bridge 61. This is apparent since the resistance values of the bridge arms opposite the arms containing the pilot arms are equal. Accordingly any resistance variation caused by resistance variations of the pilot line 59 will be compensated by an equal variation in the pilot line 60. If temperature variations occur in the above ground section 54 of the transmission line, the resistance of the pilot line 60 will be varied to effect operation of the bridge circuit 61. In the circuit under consideration it is assumed that the above ground section 54 of the transmission line 53 is located some distance from the repeater or control station so that a single pilot line cannot be employed for controlling the transmission line attenuation in accordance with the temperature variations of the above ground section 54.

The galvanometer 68 operates galvanometer control mechanism 69 of the type disclosed in the above mentioned application of I. G. Wilson Serial No. 69,658. The galvanometer control mechanism 69 not only operates a shaft 70 for operating the switch arm 66 and the resistance 65 to balance the bridge circuit, but also controls two switches 71 and 72. The switch 71 when operated completes a circuit from battery 73 for operating a relay 74. The switch 72 when operated completes a circuit from the battery 75 for operating a relay 76. The relay 74 when operated completes a circuit from a battery 77 for operating a motor 78 in one direction. The relay 76 when operated completes a circuit from the battery 77 for operating the motor 78 in a reverse direction. The motor 78 by means of gearing 79 and a shaft 80 operates the switch arm 58 controlling the potentiometer 57.

In the circuit disclosed in Fig. 2 of the drawings the two pilot lines 59 and 60 connected to the balanced arms of the bridge 61 take care of the difference in lengths of the transmission line sections and the difference in attenuation temperature coefficients so that operation of the bridge 61 is effected only in accordance with the temperature variations in the above ground section 54 of the transmission line. The bridge 61 effects operation of the galvanometer 68 which, in turn, effects operation of the galvanometer control mechanism 69 for operating the switch arm 66 and one of the switches 71 and 72. The switches 71 and 72 are selectively operated according to whether or not the line attenuation is to be raised or lowered. The switches 71 and 72 control the relays 74 and 76 which, in turn, control the motor 78 to adjust the potentiometer 57.

Referring to Fig. 3 of the drawings a circuit is shown which is very similar to the circuit shown in Fig. 2, but in which the bridge circuit is balanced in a very different manner. The circuit shown in Fig. 3 employs a single bridge circuit and two pilot lines for controlling the attenuation of a transmission line not only in accordance with the temperature variations of an underground section, but also in accordance with temperature variations of an above ground section. The circuit connections of the bridge circuit 81 shown in Fig. 3 of the drawings are exactly the same as the circuit connections shown in the bridge circuit 61 in Fig. 2 of the drawings. The bridge 81 is provided with three fixed resistance elements

R_1 , R_2 and R_3 and a variable resistance R_4 which is controlled by a switch arm 82 in the same manner as the resistance 65 in Fig. 2 of the drawings is controlled by the switch arm 66. The conductors 83 joined to one arm of the bridge 81 are connected to a pilot line 59 associated with the underground section of a transmission line as shown in Fig. 2 of the drawings. The conductors 84 joined to an adjacent arm of the bridge 81 are connected to a pilot line associated with the underground section and the above ground section of the transmission line as the pilot line 60 shown in Fig. 2 of the drawings.

The resistance R_2 in one arm of the bridge is balanced with the resistance of the pilot line associated with the underground section of the transmission line. The resistance R_3 plus the resistance R_4 is balanced against a resistance R_1 and the pilot line associated with the underground section and the above ground section of the transmission line. The resistance R_2 considered against the resistance elements R_3 and R_4 are unequal so that a variation in either pilot line will unbalance the bridge 81. The resistance elements R_1 , R_2 and R_3 are determined so that the pilot line associated with the underground section and the above ground section of the transmission line operates the bridge in accordance with the temperature variations of the above ground section, and the two pilot lines operate the bridge in accordance with temperature variations in the underground section of the transmission line. The bridge 81 controls the potentiometer in the transmission line in the same manner as the bridge shown in Fig. 2 of the drawings. However, the bridge 81 shown in Fig. 3 of the drawings is operated to control the transmission line attenuation not only in accordance with the underground section, but also in accordance with the above ground section.

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 combination, a signal transmission line having sections thereof subjected to different temperature conditions, a number of pilot lines associated with the line sections, a bridge circuit, means for controlling said bridge simultaneously by the pilot lines and for differentiating for the attenuation temperature coefficients of the different line sections, and means governed by said bridge circuit for controlling the transmission line attenuation and for balancing the bridge circuit.

2. In combination, a signal transmission line having sections thereof subjected to different temperature conditions, a number of pilot lines associated with the transmission line sections, a bridge circuit, means for controlling said bridge simultaneously by the pilot lines while differentiating for the attenuation characteristics of the different line sections, and means governed by said bridge circuit for controlling the transmission line attenuation.

3. In combination, a signal transmission line having two sections of different lengths subjected to different temperature conditions, two pilot lines associated with said line sections, a bridge circuit, means for controlling said bridge simultaneously by said pilot lines while differentiating for the lengths of the line sections, and means controlled by said bridge for governing the line attenuation and for balancing the bridge circuit.

4. In combination, a signal transmission line having sections of different lengths subjected to different temperature conditions, a number of pilot lines associated with the line sections, a bridge circuit, means for controlling said bridge simultaneously by the pilot lines and for differentiating for the lengths and the attenuation temperature coefficients of the transmission line sections associated with the pilot lines, and means governed by said bridge circuit for controlling the transmission line attenuation and for balancing the bridge circuit.

5. In combination, a transmission line having a portion located above ground and a portion located underground, a pilot line subjected to the same transmission varying conditions as the portion of line located above ground, a second pilot line subjected to the same transmission varying conditions as the portion of the line located underground, a bridge circuit, means for controlling said bridge simultaneously according to the resistance variations of said pilot lines, and means controlled by said bridge for maintaining the transmission line attenuation constant and for balancing the bridge circuit.

6. In combination, a transmission line having two sections subjected to different attenuation varying conditions, a pilot line associated with each of said sections and subjected to the same attenuation varying conditions as the line sections, a bridge circuit, means for controlling said bridge simultaneously according to the resistance variations of said pilot lines, and means controlled by said bridge for maintaining transmission line attenuation constant and for balancing the bridge circuit.

7. In combination, a transmission line having two sections subjected to different temperature conditions, a pilot line associated with each of said line sections, a bridge circuit having two resistance elements respectively corresponding in values to the lengths and attenuation temperature coefficients of said line sections, means for varying said resistance elements according to the resistance variations of said pilot lines, and means controlled by said bridge for governing the transmission line attenuation and for balancing the bridge.

8. In combination, a transmission line having a section located underground and a section located above ground, two pilot lines respectively associated with said line sections and subjected to the same temperature varying conditions as the line sections, a bridge circuit having two impedance elements respectively corresponding in values to lengths and attenuation temperature coefficients of said line sections, means for varying said impedance elements according to the resistance variations of said pilot lines and means controlled by said bridge for maintaining the transmission line attenuation constant and for balancing the bridge.

9. In combination, a transmission line having a section located underground and a section located above ground, a pilot line associated with the underground line section, a pilot line associated with the above ground section of the line, each of said pilot lines forming the arm of separate secondary bridge circuits, a main bridge circuit having impedance elements in one arm thereof respectively controlled according to the operation of said secondary bridge circuits, said elements having impedance values corresponding to the lengths and the attenuation temperature coefficients of said line sections, means for

varying the impedance elements in the arm of the main bridge according to the unbalancing of the secondary bridge circuits by said pilot lines and means controlled by the main bridge circuit for maintaining the transmission line attenuation constant.

10. In combination, a transmission line having two sections subjected to different temperature conditions, a pilot line subjected to the same temperature conditions as one of said line sections, a pilot line subjected to the same temperature conditions as both of said line sections, a balanced bridge circuit having said pilot lines respectively inserted in adjacent arms of said bridge to control the bridge solely according to the attenuation variations of only one of said line sections, and means controlled by said bridge for governing the line attenuation and for balancing the bridge circuit.

11. In combination, a transmission line having a section located above ground and a section located underground, a pilot line subjected to the same attenuation varying conditions as the section of said line located underground, a second pilot line subjected to the same attenuation varying conditions as the underground line section and the above ground line section, a balanced bridge circuit having adjacent bridge arms including different ones of said pilot lines, and means controlled by said bridge for governing the transmission line attenuation according to the attenuation variations of the line section located above ground.

12. In combination, a transmission line having a section located above ground and a section located underground, a first pilot line subjected to the same attenuation varying conditions as the section of said line located underground, a second pilot line subjected to the same attenuation varying conditions as the underground line section and the above ground line section, a balanced bridge circuit having one arm formed by said second pilot line and an adjacent arm formed by the first pilot line with resistance to balance the arm formed by the second pilot line, and means controlled by said bridge for governing the transmission line attenuation according to the attenuation variations of the line section located above ground.

13. In combination, a signal transmission line having two line sections subjected to different temperature conditions, a pilot line associated with and subjected to the same temperature conditions as one of said line sections, a pilot line associated with and subjected to the same temperature conditions as both of said line sections, a balanced bridge circuit having said pilot lines respectively inserted in adjacent bridge arms, the bridge arms opposite the bridge arms including said pilot lines having resistance value determined according to the lengths and attenuation temperature coefficients of said line sections for operating the bridge by variations in resistance of one of said pilot lines according to the attenuation temperature changes of the line by one section thereof and for operating said bridge by the variations in resistance of the other pilot line according to the attenuation temperature changes of the line by the other section thereof, and means controlled by said bridge for maintaining the line attenuation constant.

14. In combination, a signal transmission line having a section located above ground and a section located underground, a pilot line subjected to the same temperature varying conditions as the section of said line located underground, a second pilot line subjected to the same temperature varying conditions as the line section located underground and the line section located above ground, a balanced bridge circuit having said pilot lines respectively inserted in adjacent bridge arms, the arms of said bridge opposite to the arms including said pilot lines having different resistance values determined according to the lengths and attenuation temperature coefficients of the two line sections for insuring differential operation of the bridge according to the attenuation variations of each line section by temperature variations, and means controlled by said bridge for maintaining the transmission line attenuation constant and for rebalancing the bridge.

15. In combination, a signal transmission line having two line sections subjected to different temperature conditions, a pilot line subjected to the same temperature conditions as one of said line sections, a pilot line subjected to the same temperature conditions as both of said line sections, a balanced bridge circuit having said pilot lines respectively inserted in adjacent bridge arms, the arms of said bridge opposite to the arms including said pilot lines having different resistance values for operating said bridge by variations in resistance of one of said pilot lines according to the attenuation temperature changes of the line by one section thereof and for operating said bridge by the other pilot line according to the attenuation temperature changes of the line by the other section thereof, and means controlled by said bridge for maintaining the line attenuation constant.

16. In combination, controllable apparatus having parts thereof subjected to different temperature conditions, a number of measuring means associated with the different parts of the apparatus, a bridge circuit, means for controlling different arms of said bridge circuit by said measuring means and for differentiating for different effects on said apparatus caused by changes of temperature in different parts thereof, and means governed by said bridge circuit for governing controllable apparatus to correct for the effects of changes of temperature in different parts thereof and for balancing the bridge circuit.

17. In combination, controllable apparatus, a bridge circuit, means for varying the impedance of one bridge arm according to variations in a condition of one part of said controllable apparatus, means for varying the impedance of an adjacent bridge arm according to variations in a condition of the first part of the controllable apparatus and another part of said controllable apparatus, the arms of said bridge opposite to the controllable arms having different impedance values for operating said bridge according to variations in the condition of both parts of said controllable apparatus and means controlled by the bridge for governing the controllable apparatus.

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