

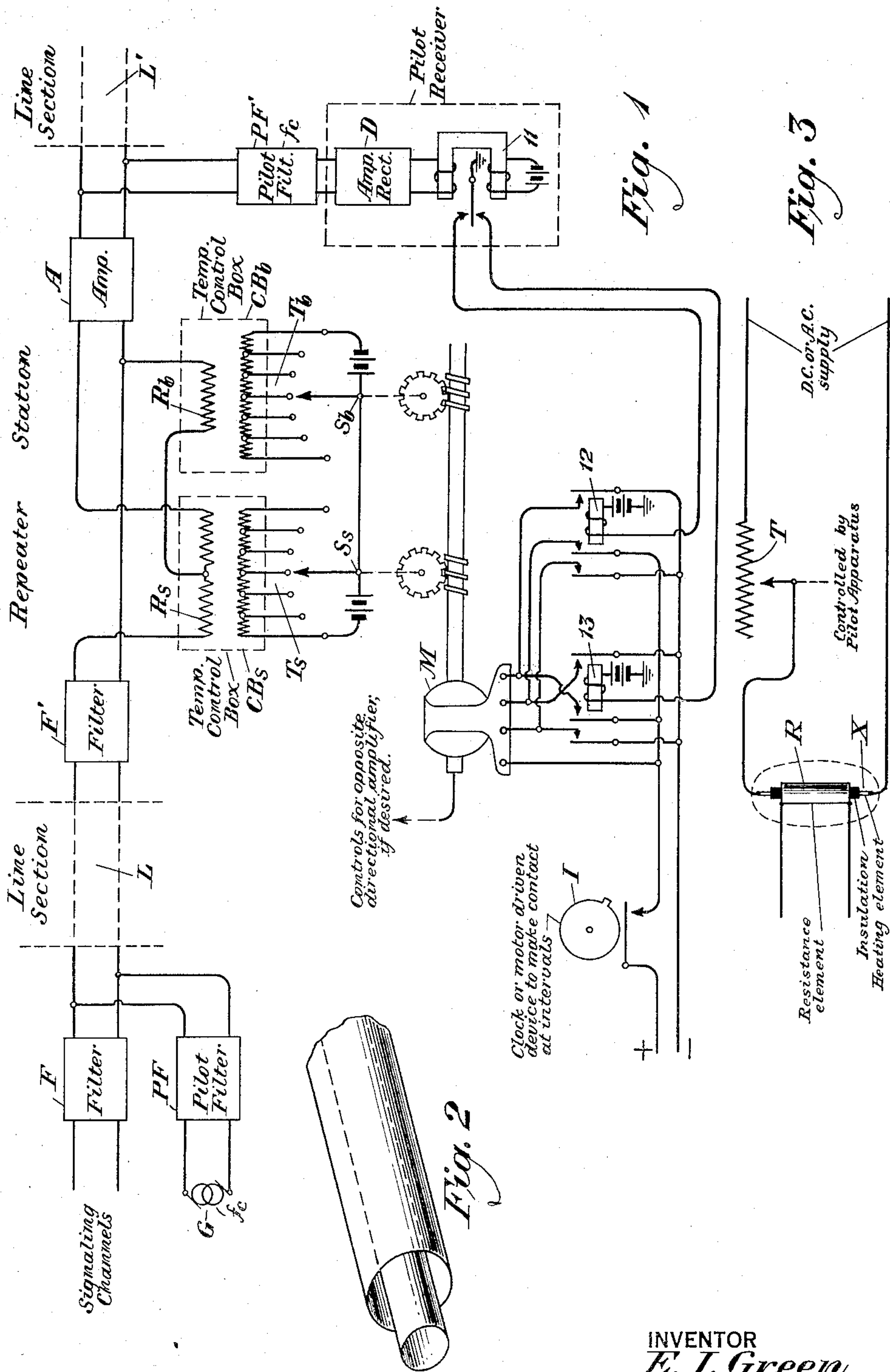
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TRANSMISSION CONTROL

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TRANSMISSION CONTROL

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This invention relates to arrangements for maintaining constant the transmission equivalent of a transmission circuit, and more particularly to such an arrangement which compensates for changes in attenuation of the system due to temperature variations.

In any transmission system, changes in attenuation occur with variations in the temperature of the transmission conductors. In the case of cable circuits, these attenuation changes are very important at voice frequencies and it is desirable to have some arrangements for compensating for the attenuation changes due to temperature variation. In the case of open wire circuits the temperature changes are not so important, particularly at carrier frequencies, as the attenuation change is largely due to variable weather conditions. In the case of the concentric conductor type of system, however, the system is not affected by weather changes, but owing to the extremely high frequencies involved the temperature changes affecting the material of the conductors themselves become very important. Here, again, it is desirable to have some arrangement for compensating for the changes in temperature.

In accordance with the present invention, a transmission regulator is provided which does not involve any contacts in the transmission circuit itself. The regulator includes a pilot channel applied to the transmission circuit in such manner that at the regulator point the pilot frequency is received at an amplitude which is a function of the attenuation of the system. As the attenuation of the system varies with temperature, the amplitude of the received pilot frequency varies in a corresponding manner and this variation is used to control the adjustment of a multi-contact switching arrangement involving two adjustable rheostats heated by current flowing through them. As the switching elements of the rheostats are adjusted, more or less resistance is cut into the rheostats, thereby changing the amount of heat generated by each rheostat. The switches are so arranged that as the one rheostat is increased in temperature, the other rheostat is decreased in temperature and vice versa. These

rheostats may be associated with the series resistance and shunt resistance, respectively, of a T resistance network in the transmission line so that when the attenuation of the line changes, due to a temperature variation, the series resistance will be raised in temperature and the shunt resistance lowered in temperature or vice versa, depending upon the direction of the change of attenuation. This change in the temperature of the resistance comprising the T network compensates for the change in temperature of the line conductors and thereby maintains the over-all attenuation substantially constant.

The invention also contemplates, however, that other forms of network may be used instead of the simple T network. In fact, the network may include reactance elements as well as resistance elements, and may be designed so that the thermal control of the resistance values results in different attenuation-frequency characteristics for the network. Thus if the line has an attenuation-frequency characteristic whose slope varies with changes in temperature or some other variable, the network might be designed to adjust or build-out the line characteristic to some constant slope. This adjustment would be accomplished by controlling the attenuation-frequency characteristic of the network through control of the temperature of its resistance elements.

The provision of additional networks or elements whose temperature is controlled by the means described above is also included within the scope of the invention.

The invention will now be more fully understood from the following description, when read in connection with the accompanying drawing, Figure 1 of which is a simplified circuit diagram showing one embodiment of the temperature regulating arrangement, Fig. 2 shows in symbolic form a concentric conductor type of transmission system which may be employed in connection with the line sections of the system to which the invention is applied, while Fig. 3 shows a modified temperature regulating arrangement.

Referring to Fig. 1, a transmission circuit

comprising a series of line sections such as L and L' is shown with amplifiers such as A of any known type provided at the repeater stations between the line sections. The line sections are of any known type as, for example, a pair of conductors in a telephone cable or a pair of open wires or a concentric conductor type of system such as is shown schematically in Fig. 2 and which consists of an inner and an outer cylindrical conductor concentrically arranged and separated by spacing washers (not shown) arranged at intervals along the conductors to maintain them in proper spaced relation.

As is well known, line conductors are subject to variations in attenuation due to changes in the resistance of the conductors resulting from temperature variations, and this is particularly important where a concentric conductor system is employed, as the concentric conductor system is not subject to changes in attenuation due to weather variations, and practically its only change in attenuation is due to temperature effects. It is therefore proposed by the present invention to provide means to compensate for the temperature effects, and such means may comprise temperature control boxes CB_s and CB_b, said control boxes containing adjustable elements. For example, the control box CB_s contains a series resistance R_s and the control box CB_b contains a shunt resistance R_b, these two resistance elements being arranged to form a so-called T network or artificial line which is included in the transmission circuit. By adjusting the resistance of the elements of such T network, the T network may be made to compensate for changes in the attenuation of the actual physical line sections. In the present case this change in the resistance of the elements R_s and R_b is accomplished without including any contact elements in the line by variably heating said elements through the agency of heating rheostats or thermal devices T_s and T_b included in the temperature control boxes CB_s and CB_b, respectively. These rheostats are adjustable by means of switches S_s and S_b which may be rotated by the motor M to cut in and out more or less of the elements of each rheostat and thereby varying the temperature due to the flow of current through the rheostats. The adjustable switches S_s and S_b are so controlled by the motor M that when one is adjusted in such a direction as to increase the temperature of the rheostat, the other one will be adjusted in such a direction as to decrease the temperature of the rheostat, and vice versa.

In order to control the operation of the motor M in accordance with changes in the attenuation of the line sections of the transmission line due to temperature variations, a pilot channel is provided by means of which a frequency f_c generated by a source G is

applied to the line and received at the repeater point. The pilot frequency is applied to the line through a pilot filter PF which passes the pilot frequency but prevents signaling frequencies from the signal channels from being diverted into the pilot terminal apparatus. Signal frequencies are, of course, applied to the line section through a suitable filter F which passes the signal frequencies but prevents the pilot frequency from entering the signal terminal. At the repeater station a filter F' is provided which passes both signaling channels and the pilot frequency to the repeater A through the elements of the T network. Since the temperature control will change the impedance of the network which is shown, it might be well to divide the amplifier into two sections and place the network between them. Such a change is indicated on the drawing by an amplifier box A' between F' and the resistance network. On the output side of the amplifier A the receiving apparatus for the pilot frequency is connected, and this apparatus consists of a pilot filter PF' for selecting the pilot frequency f_c , an amplifying and rectifying arrangement D for translating the pilot frequency into a direct current, and a receiving relay 11 for responding to the direct current. The armature of the receiving relay 11 is connected to close the circuit of either the relay 12 or the relay 13, the contacts of said relays being arranged to close circuits whereby the motor M will rotate in one direction or the other whenever the power circuit is closed by the clock or motor-driven interrupting device I.

Under normal conditions, if the pilot frequency is received at a certain normal amplitude the armature of the relay 11 will occupy a neutral position and no effect upon the motor control arrangement results. If, due to a temperature change the attenuation of the line circuit is affected, the amplitude of the pilot frequency received at the repeater station will be changed and the armature of the receiving relay will be thrown against one or the other of its contacts, depending upon whether the pilot frequency is received at an increased or decreased amplitude. When the armature of the receiving relay 11 is thrown to one contact, as soon as the interrupter I closes the power circuit the motor M rotates in such a direction that the switches S_s and S_b are in turn rotated to increase the temperature of the rheostat T_s and to decrease the temperature of the rheostat T_b. This results in an increase in the temperature of the series element R_s of the network and a decrease in the temperature of the shunt element R_b of the T network, thereby producing changes which tend to compensate for the change in attenuation of the transmission line. If the adjustment due to one pulse from the interrupter I through the

motor *M* is insufficient to fully compensate for the changes in attenuation in the transmission line, the armature of the relay 11 will still remain upon the same contact and a further adjustment in the same direction will take place with the next impulse, and this operation will be continued until the change in attenuation in the line is fully compensated.

If the change in amplitude of the pilot frequency is in the opposite direction so that the armature rests upon the opposite contact, the motor *M* will now rotate in the opposite direction as soon as a pulse from the interrupter *I* is received and cause such an adjustment of the rheostats that the temperature of the series resistance R_s of the *T* network is decreased and the temperature of the shunt resistance R_b of the network *T* is increased. This reduces the attenuating effect of the *T* network and thereby compensates for the change in attenuation of the line. As before, if the adjustment due to one pulse from the interrupter *I* is insufficient to fully compensate for the change in the transmission line, the adjustment will continue for successive impulses until the armature of the relay is returned to its neutral position, which occurs when the pilot frequency is received at normal amplitude.

It will be seen, therefore, that the resultant effect of the pilot apparatus is to make such momentary adjustments as will tend to keep the received pilot frequency at constant amplitude, thereby indicating that the over-all transmission equivalent of the line circuit is being maintained substantially constant.

It will also be noted that these results are obtained without the use of contact elements in the transmission line, the contact elements merely affecting the adjustable rheostats which are not directly included in the line.

Instead of being controlled by a pilot channel current whose magnitude is an index of the line attenuation, the temperature of the network may be controlled by some other equivalent means.

The arrangement for heating the resistance elements of the network may be made similar to those arrangements commonly employed for heating the cathode in an equipotential or heater-type of vacuum tube. Thus the heating element might be a resistance unit *X* composed, for example, of tungsten or tungsten alloy, while the resistance element *R* whose temperature is to be regulated may be supported concentrically around the heating element but insulated therefrom. A possible arrangement of this kind is shown in Fig. 3.

The network having resistance elements which are subject to thermal control is not limited to use in association with a line circuit as a means of compensating for changes in line attenuation. Such a network may be inserted, for example, in any type of trans-

mission circuit or apparatus as a means of regulating the gain or loss without requiring moving contacts in the main transmission circuit. The temperature of the network elements may be controlled manually or may be adjusted automatically in response to the variations occurring in some pilot channel or index.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a transmission system, a transmission line, means for applying electrical signals to said line, an auxiliary resistance in said line, said resistance being variable with temperature, and means controlled by said line to vary the temperature of said resistance to compensate for changes of resistance of said line.

2. In a transmission system, a transmission line, means for applying electrical signals to said line, an auxiliary resistance in said line, said resistance being variable with temperature, and means controlled in accordance with the transmission equivalent of the line proper to vary the temperature of said resistance to compensate for changes in the transmission equivalent of said line.

3. In a transmission system, a transmission line, a network including resistance in series with the line and resistance in shunt with the line, said resistance being variable with temperature, and means controlled by said line to vary the temperatures of said resistances to compensate for changes of resistance of said line.

4. In a transmission system, a transmission line, a network including resistance in series with said line and resistance in shunt with said line, said resistance being variable with temperature, and means controlled in accordance with the transmission equivalent of the line proper to vary the temperatures of said resistances to compensate for changes in the transmission equivalent of said line.

5. In a transmission system, a transmission line, a network including resistance in series with the line and resistance in shunt with the line, said resistance being variable with temperature and means controlled by said line to oppositely vary the temperatures of said resistances to compensate for changes of resistance of said line.

6. In a transmission system, a transmission line, a network including resistance in series with said line and resistance in shunt with said line, said resistance being variable with temperature, and means controlled in accordance with the transmission equivalent of the line proper to oppositely vary the temperatures of said resistances to compen-

sate for changes in the transmission equivalent of said line.

7. In a transmission system, a transmission line, means for applying electrical signals to said line, an auxiliary resistance in said line, said resistance being variable with temperature, a variable heating element for varying the temperature of said resistance, and means controlled by said line for varying said heating element.

8. In a transmission system, a transmission line, means for applying electrical signals to said line, an auxiliary resistance in said line, said resistance being variable with temperature, a variable heating element for varying the temperature of said resistance, and means controlled in accordance with the transmission equivalent of the line proper to vary said heating element.

9. In a transmission system, a transmission line, a network including resistance in series with the line and resistance in shunt with the line, said resistance being variable with temperature, variable heating elements for varying the temperatures of said resistances, and means controlled by said line for oppositely varying said heating elements.

10. In a transmission system, a transmission line, a network including resistance in series with the line and resistance in shunt with the line, said resistance being variable with the temperature, variable heating elements for varying the temperatures of said resistances, and means controlled in accordance with the transmission equivalent of the line proper for oppositely varying said heating elements.

11. In a transmission system, a transmission line, means for applying electrical signals to said line, an auxiliary resistance in said line, said resistance being variable with temperature, a variable heating element for varying the temperature of said resistance, means to transmit a pilot frequency over said line, and means controlled by said pilot frequency for varying said heating element in accordance with the amplitude of the received pilot frequency.

12. In a transmission system, a transmission line, a network including resistance in series with the line and resistance in shunt with the line, said resistance being variable with temperature, variable heating elements for varying the temperatures of said resistances, means to transmit a pilot frequency over said line, and means controlled by said pilot frequency for oppositely varying said heating elements in accordance with the amplitude of the received pilot frequency.

13. In a transmission system, a transmission line, means for applying electrical signals to said line, an attenuating network connected in said line, said network including elements whose resistance varies with temperature and means controlled in accordance

with the line attenuation to vary the temperatures of certain elements of said network to compensate for changes in the line attenuation.

14. In a transmission system, a transmission line, an attenuating network connected in said line, said network including elements whose resistance varies with temperature, and means controlled in accordance with the line attenuation to vary the temperatures of at least some of the elements of said network, the temperature of certain of said elements being regulated in opposite manner from that of other of said elements.

15. In a transmission system, a transmission line, an attenuating network connected in said line, said network including elements whose resistance varies with temperature, and means to control the temperatures of certain of said elements by energy supplied from an external source.

16. In a transmission system, a transmission line, an attenuating network connected in said line, said network including elements whose resistance varies with temperature, and means to control the temperatures of certain of said elements by energy supplied by an external source in accordance with changes occurring in the resistance of said transmission line.

17. In a transmission system, a transmission line having an attenuating network connected thereto, said network including elements whose resistance is determined by temperature, auxiliary means to heat said elements, and means to control the heating action of auxiliary means in accordance with variations in the attenuation of said line.

18. In a circuit for the transmission of a band of frequencies, a network whose attenuation-frequency characteristic is dependent upon the resistance of certain of its elements, the resistance of said elements being variable with temperature, and means for controlling the temperatures of said elements in accordance with a single one of the frequencies transmitted.

19. In a transmission system, a transmission line, means for applying to said line a band of signal frequencies, an attenuating network connected to said line, said network having an attenuation-frequency characteristic which is dependent upon the resistance of certain of its elements, the resistance of said elements being variable with temperature, and means for controlling the temperatures of said elements in accordance with a single one of said frequencies.

20. In a transmission system, a transmission line, means for applying to said line a band of signal frequencies, an attenuating network connected to said line, said network having an attenuation-frequency characteristic whose slope is dependent upon the resistance of certain of its elements, the resist-

ance of said elements being variable with temperature, and means for controlling the temperatures of said elements in accordance with a single one of said frequencies.

5 21. In a system for the transmission of electrical signals, a transmission line transmitting a band of frequencies, an attenuating network connected to said line, said network including elements whose resistance varies
10 with temperature, and means to control the temperatures of said elements in accordance with the received magnitude of a pilot frequency selected from the band of frequencies.

15 22. In a system for the transmission of intelligence, the method of compensating for changes in the attenuation of a line circuit for a band of signal frequencies transmitted

over said line circuit, which consists in transmitting over said line circuit a pilot frequency, passing said band of signal frequencies through a network whose attenuation is
70 determined by the temperature of certain of its elements, and controlling the temperatures of said elements in accordance with the magnitude of the pilot frequency received from said line.

23. In a circuit for the transmission of electrical signals, an attenuating network, said
75 network including elements whose impedance varies with temperature, and means to control the temperatures of certain of said elements by energy supplied from an external
80 source.

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