

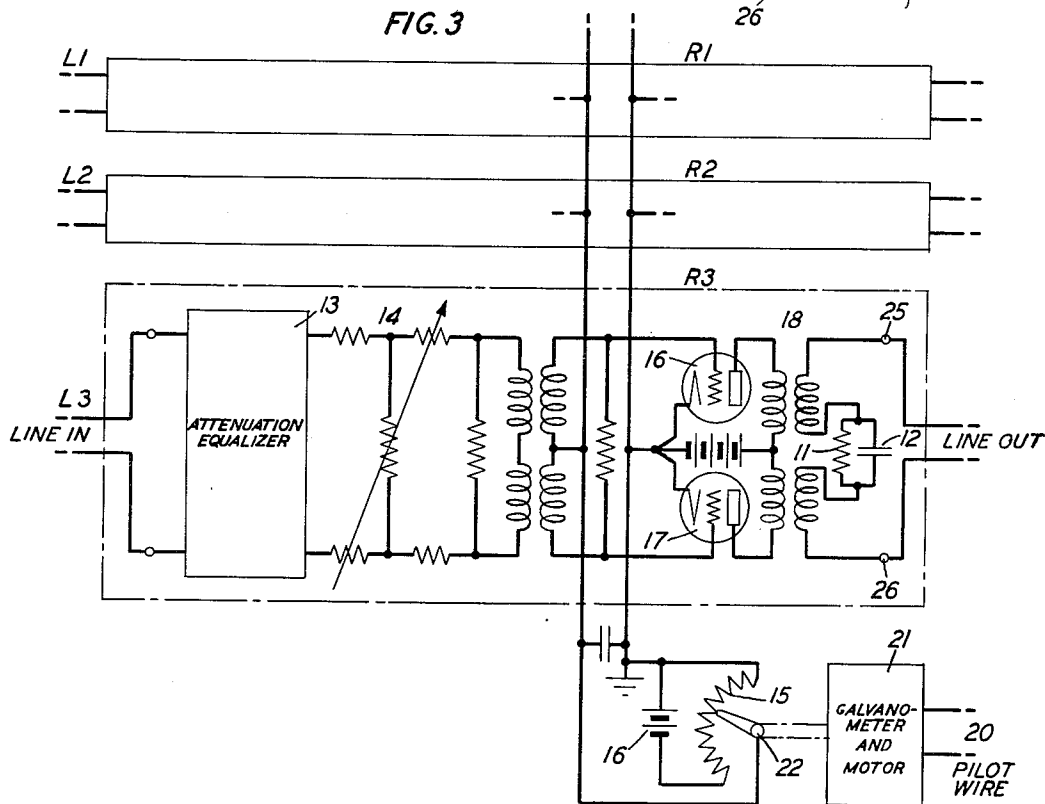
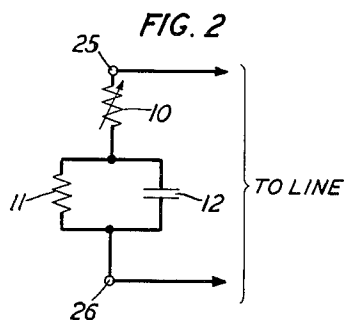
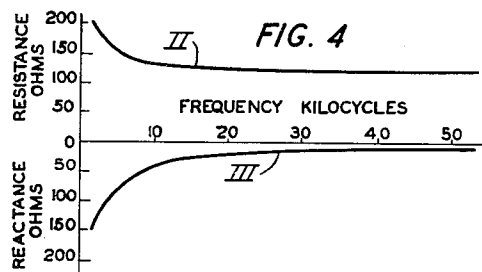
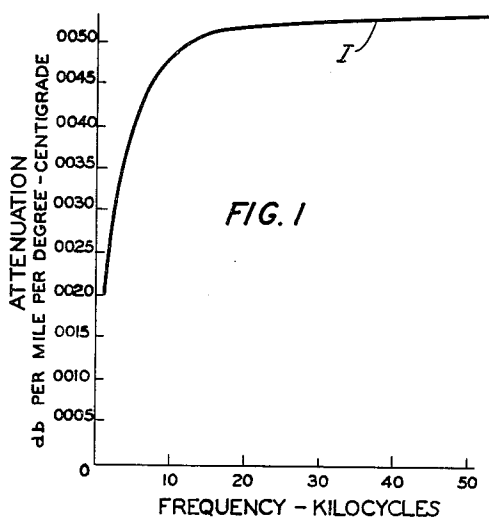
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CORRECTION FOR CHANGES IN LINE TRANSMISSION

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CORRECTION FOR CHANGES IN LINE
TRANSMISSION

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6 Claims. (Cl. 178-44)

The present invention relates to method and means of variably controlling the transmission characteristics of a line or circuit to compensate for changes in characteristic due to temperature variations or some other cause.

It is an object of the invention to effect required changes in transmission characteristic by changing the internal impedance of a space discharge device, preferably in a gradual or continuous manner.

A further object is to control the characteristics of a number of circuits or lines by a unitary control of simplified construction.

In a long telephone line exposed to the elements or in an underground telephone cable which experiences only variations in temperature, the transmission characteristics change in greater or lesser amounts depending on the nature and extent of change of the factors influencing the transmission, and various means are known in the art for introducing corrective variations in the characteristics of the system.

The present invention, while capable of general application, will be described with particular reference to a telephone toll cable containing a large number of pairs (e. g. 68) of 16 and 19 gauge conductors, used for speech and carrier wave transmission from any lower frequency limit up to the order of 50 kilocycles. In such a system the repeater spacing may be as close as 25 miles, resulting in the use of 160 repeater stations in tandem in a 4000 mile cable. At each repeater station on such a cable there are 68 separate repeaters, usually of the push-pull or balanced type and each consisting of one or preferably more than one stage.

The transmission requirements on such a system are very high, and necessitate close regulation. Devices are known which either automatically or manually control a potentiometer in the line or repeater circuit to change the amount of gain to compensate for variations in transmission characteristics. One drawback to such devices from the standpoint of the system under consideration is that a potentiometer per repeater is required, and this results in the use of a large amount of regulating equipment.

In accordance with the present invention, compensation is accomplished by a single device for a group of repeaters, or for all of the repeaters, at each repeater station, regardless of the number of repeaters employed. This device may take the form of a potentiometer in the grid biasing circuit of all of the repeaters, and may be operated automatically or manually to control the

internal impedances of the repeaters in a manner to be described in detail hereinafter.

In the attached drawing, to which reference is made in the description to follow, Figs. 1 and 4 show typical graphs of the rate of variation of line attenuation over the frequency transmission range per degree change of temperature, and of line transmission characteristics, respectively;

Fig. 2 shows a schematic drawing of a compensating network of a type to correct for transmission variations such as indicated in Fig. 1; and

Fig. 3 is a schematic circuit diagram of a system embodying the invention for accomplishing such compensation.

The manner in which the attenuation of an underground telephone cable circuit varies per degree change of temperature over the transmission frequency range is shown by the typical curve I of Fig. 1. Since this is not a straight line, the rate of variation is seen to vary with frequency and to be greater at the higher frequencies than at the low. The rate of change of attenuation with frequency varies rapidly throughout the lower portion of the range represented but is nearly constant in the higher frequency region.

From this it follows that an impedance capable of being varied so as to compensate for the attenuation changes indicated by curve I must have a more rapid rate of variation at the high frequencies than at the low.

It is desirable for practical considerations to arrange the compensating impedance so that variation of a single element, preferably a resistance, will effect the necessary compensation.

Since a given change in a resistance will produce a greater effect in a low impedance circuit than in a high impedance circuit, it is possible, by associating proper impedance elements with the variable resistance, to make the rate of change of attenuation with frequency of the network follow the curve of Fig. 1, the actual attenuation changes thus produced in the network being opposite in sign to the corresponding changes in line attenuation. For example, a network of the type shown in Fig. 2 was found suitable in a particular case, the variable resistance being 10. At low frequencies resistance 11 is effectively included in the circuit so that variation of resistance 10 produces less total effect than as if resistance 11 were absent. At very high frequencies resistance 11 is virtually absent on account of the low shunting impedance of con-

denser 12. By proportioning the elements 10, 11 and 12 it is possible to make the variations in total attenuation of the network, due to changes in resistance 10, equal and opposite to the variations in line attenuation for a given change in temperature at all frequencies in the transmitted range.

With this general explanation it is believed that the embodiment of the invention represented by the circuit of Fig. 3 will be readily understood.

This figure shows in simple schematic form a repeater point in a cable comprising a multiplicity of lines of which three are indicated, at L₁, L₂ and L₃. Each line contains an amplifying repeater R₁, R₂ and R₃, which may be all alike. This repeater preferably comprises a pair of amplifier tubes in push pull. Each line is provided with other equipment as necessary in any given case, such as an attenuation equalizer 13, and gain control pad 14 which may be operated either manually or automatically to adjust the gain to the required level.

In accordance with this invention, there is included in the output connection of each repeater R₁, R₂, R₃, etc., a network 11, 12 such that with adjusted values of the repeater output impedance, the combination compensates for variations in line attenuation due to temperature (or like) changes. That is, the series variable resistance 10 of Fig. 2 is incorporated in the repeater internal output impedance of Fig. 3. This resistance is varied by changing the grid bias obtained from potentiometer 15 shunting the grid battery 16.

Let it be assumed that the internal output impedance (R₀) of each of the tubes 16 and 17 is one-half the proper value for the resistance represented by 10 in Fig. 2 when the line has its maximum temperature and therefore its greatest attenuation. Since the signal currents flow serially through the space paths of tubes 16 and 17 and through the primary of output transformer 18, the impedance of the two tubes together is twice that of one, and is the proper value for the condition assumed. If then, the line attenuation decreases due to temperature decrease, it is only necessary to adjust the potentiometer 15 to a new point such that the internal resistance (R₀) of the tubes shifts to a proper larger value. This is equivalent to increasing the resistance introduced through output transformer 18 from tubes 16, 17 into the secondary in series with elements 11 and 12 and is equivalent to varying resistance 10 of Fig. 2.

The potentiometer 15, it will be noted, controls the grid bias of all of the repeaters R₁, R₂, etc., as well as that of R₃ so that the adjustment of this one potentiometer effects a compensation in all of the repeaters associated with all of the cable circuits.

While adjustment of the potentiometer 15 may be made manually, it has been shown provided with an automatic control operated in response to resistance variations in pilot wire 20 by means of a suitable galvanometer and motor mechanism 21. The latter may be constructed in the manner disclosed, for example, in A. B. Clark Patent 1,438,219, patented December 12, 1922. The pilot wire 20 is included in the same cable as lines L₁, L₂, L₃, etc., and is thus subject to the same temperature changes. As its resistance changes, the motor mechanism causes shaft 22 to rotate clockwise or counter-clockwise, depending upon the direction in which the resistance change takes place. This in turn moves the slid-

ing contact on the potentiometer 15. Any other suitable mode of control may be used.

In a particular case where the line had the transmission constants indicated by the curves II and III of Fig. 4, and the variation in attenuation with frequency was according to curve I of Fig. 1, suitable values were: for resistance (11), 168 ohms; for condenser (12), 0.26 microfarads; and for the minimum value of resistance (10) (corresponding to maximum line temperature), 131 ohms. In Fig. 3, therefore, the resistance of the plate circuits of tubes 16 and 17 as seen looking back from the secondary side of transformer 18, should be 131 ohms, minimum. With decrease in temperature the negative grid bias should be increased to increase the R₀ of each tube to the value

$$R_0 + \frac{T \cdot R_0}{2 \cdot 131}$$

where T is the required change in resistance 10 of the network in Fig. 2.

In the particular example given, the impedance of the network 10, 11, 12 of Fig. 2 as measured between terminals 25 and 26 for maximum temperature condition was substantially equal to the characteristic impedance of the line. Similarly, in Fig. 3, the impedance to the left of terminals 25, 26 equalled the characteristic impedance of the line to the right of these terminals in the drawing. Increase in R₀ therefore amounts effectively to inserting resistance between two circuits of nominally the same characteristic impedance.

It is to be understood that the invention is not limited to the details that have been shown and described, but is capable of various changes and modifications. For example, the control that compensates for change in line characteristic may be exerted on a grid in each tube separate and distinct from the grid to which the signal waves are applied, by varying the polarizing voltage applied to such grid in the same manner as illustrated or in any other suitable manner.

What is claimed is:

1. The method of transmission control in a system employing a space discharge device as a transmission element comprising varying the internal resistance of said device as a function of change of transmission characteristic of the system and utilizing such variations in internal resistance to effect impedance variations in the outgoing circuit which bear a non-uniform relation with frequency of waves being repeated to maintain the overall transmission characteristic substantially constant for different temperatures and throughout the transmission frequency range.

2. In a system employing circuits subject to the same change in transmission characteristic due to temperature or other variations, a space discharge device in each circuit, means common to said devices for controlling the internal resistance of said devices as a function of change of transmission characteristic of said circuits and means individual to said devices for causing a given change in internal resistance of a said device to produce non-uniform attenuation changes at different frequencies.

3. In a system comprising a signal transmission line subject to a change in attenuation due to temperature or other variations, a space discharge tube repeater in said line, and means controlling the internal impedance of said tube at a rate slow in comparison with signal variations,

and as a function of change of attenuation of said line, and to an extent sufficient to compensate the effect of said changes in attenuation, and an impedance network in the output circuit of said space discharge tube for governing the rate at which given changes in internal resistance of said tube cause the output impedance of the repeater to vary throughout the transmitted frequency range.

4. In a system comprising a signal transmission line subject to a change in attenuation due to temperature or other variations, a space discharge tube repeater in said line, and means controlling the internal impedance of said tube at a rate slow in comparison with signal variations, and as a function of change of attenuation of said line and to an extent sufficient to compensate the effect of said changes in attenuation, comprising in the outgoing circuit of said repeater an impedance network in which the internal space impedance of said discharge tube is effectively included as an element, the elements of said network being proportioned to cause the impedance changes of said tube to effect compensation for changes in line attenuation throughout the range of frequencies transmitted.

5. In a signal transmission system, a group of lines subject to variations in attenuation and each including a repeater at a common repeating point, each repeater including a space discharge device whose characteristic depends upon a polarizing potential, a source of polarizing potential

common to said repeaters, a common means for varying the polarizing potential applied to all of said repeaters as a function of the attenuation variations of said lines to compensate the effects of such variations in attenuation, the attenuation variations of the line being different at the different frequencies in the transmitted frequency range, and an impedance network associated with each repeater for enabling the change in repeater characteristic to compensate for the attenuation variations of the line throughout the transmitted frequency range.

6. In a system for the transmission of currents of a wide range of frequencies, a line for transmitting said currents, said line being subject to variable temperature such that the line attenuation changes upon change in temperature and the changes in attenuation for a given change in temperature are different for the different frequencies transmitted, a repeater in said line comprising a space discharge device, and a network included in said line, having as one of its elements the effective internal resistance of said discharge device, said network introducing non-uniform attenuation changes at different frequencies for a given change in internal resistance of the associated discharge device to effect compensation for variation in line impedance at different frequencies throughout the transmitted frequency range.

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