April 26, 1938. C. R. ECKBERG 2,115,141

TRANSMISSION REGULATING SYSTEM

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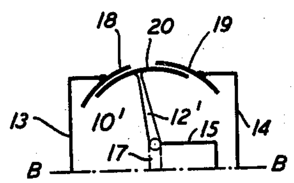

FIG. 1A

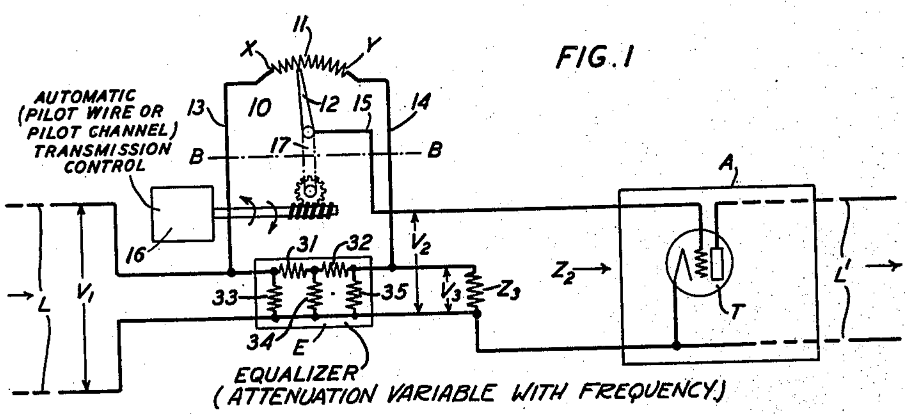

FIG. 1

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TRANSMISSION REGULATING SYSTEM

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17 Claims. (Cl. 178—44)

This invention relates to wave transmission.

An object of the invention is to control such transmission, as for instance to control wave attenuation.

A further object is to control variation of transmission with frequency, as for instance variation of attenuation with frequency.

A further object is to compensate for change of attenuation of a circuit caused by change of conditions to which the circuit is subjected, as for example temperature or other weather conditions.

A further object is to compensate for variation of the attenuation change with frequency.

A further object is to vary the compensating attenuation smoothly.

A further object is to vary the compensating attenuation with one control.

Another object is to effect the compensation in response to the change of condition that causes the change of attenuation in the circuit.

It is also an object of the invention to obtain, from an equalizer, attenuation equal to any desired proportion of the total equalizer attenuation, the proportion being the same for all frequencies of the utilized frequency range.

For transmission circuits, for example cable carrier or open wire carrier telephone circuits, often attenuation equalizing systems are required giving variable attenuation equalization to compensate, over the transmission frequency range, for attenuation changes produced in the circuits by changes of temperature or other weather conditions to which the circuits are subjected. In one specific aspect the invention is such an attenuation equalizing system, with the required variable equalization obtained by adding to the output voltage of the usual equalizer network an adjustable voltage obtained from a potentiometer whose input is connected across the series arms of that network. The sum of the two voltages is applied to the grid circuit of a vacuum tube amplifier connected in the transmission circuit. The amount of equalization effected or amount of equalizing attenuation introduced is adjusted by varying the setting of the potentiometer. The adjustment may be made by means responsive to effects of the change of condition that produces the change of line attenuation. The potentiometer may be, for example, a resistance potentiometer or an air condenser potentiometer with relatively movable plates or armatures; and the latter type of potentiometer, affording smooth regulation and freedom from make-and-break contacts or sliding contacts in the transmission circuit, and requiring but little operating power, is of special utility when the regulation is effected automatically or in response to the change of conditions that produces the line attenuation change.

The potentiometer may be of relatively low impedance, as for example in the case of a slide wire potentiometer. The effect of the bridging resistance is then considered in the design of the equalizer. It may, on the other hand, be of such high impedance, for example in the case of a condenser potentiometer, that its impedance can be disregarded without material error. The impedance into the vacuum tube amplifier should be high so that it does not materially change the impedances facing the line or equalizer network.

Other objects and aspects of the invention will be apparent from the following description and claims.

Fig. 1 of the drawing is a circuit diagram of a system embodying one form of the invention; and

Fig. 1A shows a modification of that system.

In Fig. 1 an amplifier A, comprising vacuum tubes such as T, amplifies waves received over incoming line or circuit L and transmits the amplified waves to outgoing line or circuit L′. The circuits L and L′ may be, for example, sections of a multiplex carrier cable or open wire circuit, the amplifier A amplifying simultaneously the waves of a number of carrier telephone channels and/or carrier telegraph channels, extending over a wide frequency range.

A transmission equalizing network E is provided for use in equalizing transmission variations over the carrier circuit, or compensating for variations in attenuation of the line, for example variations caused by change of temperature or other weather conditions to which the line is subjected. This network E has a suitable terminating impedance Z_3, which may match the output impedance of the network. The network E may be an attenuation equalizer with its attenuation-frequency characteristic, (for transmission through the equalizer from its input terminals to its output terminals or terminating impedance), simulating the characteristic that represents the difference between the line's highest and lowest attenuation-frequency characteristics for the range of temperature or other variations for which attenuation equalization is desired, over the utilized frequency range. The equalizer may be, for example, of the constant resistance type disclosed in Stevenson Patent 1,606,317, November 16, 1926, and Zobel Patent 1,603,305, October 19, 1926 with one or more series arms conventionally shown as generalized impedances 31 and 32 and one or more shunt arms conventionally shown as generalized impedance 33, 34 and 35. A potentiometer or voltage divider 10, comprising a resistance or impedance 11 and an adjustable contact 12 therefor, has its input leads 13 and 14 connected across the series arms of the equalizer E or so connected to the equalizer as to receive the difference between the input and output voltages of the equalizer, i. e., the difference between the voltage across the line side of the equalizer and the voltage across the equalizer terminating resistance or impedance Z_3. The output lead 15 of the potentiometer 10 is connected to the grid of the first tube T of the amplifier A. Consequently, portion Y of the potentiometer impedance 11 and the terminating impedance Z_3 of equalizer E are in serial relation to each other across the amplifier input.

V_1, V_2, and V_3 designate the equalizer input voltage, the voltage applied to the amplifier, and the equalizer output voltage respectively.

$$\frac{V_3}{V_1}$$

expresses the equalizer attenuation,

$$\frac{V_2}{V_1}$$

expresses the attenuation of that part of the potentiometer shown as X. These losses may also be considered as voltage differences and will then be expressed as V_1-V_3 and V_1-V_2. Since V_1-V_3 varies with frequency because the equalizer is designed to produce a loss variable with frequency, the voltage impressed upon the potentiometer is variable with frequency and the voltage measured between either end of the potentiometer and the contactor 12 is variable with frequency. When the contactor is at the extreme left or input, $V_2=V_1$ and no part of the equalizer loss is introduced into the transmission circuit. The transmission circuit is the circuit through which waves are passed from origin to receiver and in this description includes only a part of the circuit shown on the drawing, that is, the input line, that part of the potentiometer shown as X, amplifier A and the output line. As the contactor is moved towards the right it will be evident that the voltage between it and the left connection 13 is subtracted from the input voltage V_1 and since it is variable with frequency the resultant voltage V_2 will be the input voltage minus some portion of the voltage difference between the input and output equalizer voltage. This is equivalent to adding into the transmission circuit an equalizer readily variable from zero to maximum loss in small steps. When the contactor is at the extreme right $V_2=V_3$ and all the equalizer loss is in the transmission circuit.

The action of the potentiometer may also be considered as adding to the output voltage of the equalizer, V_3, the voltage between the contactor and the right connection 14. This is equivalent to removing from the transmission circuit an equalizer readily variable from maximum to zero loss in small steps.

The grid voltage V_2 is expressed by the equation

$$V_2=V_1-(V_1-V_3)\frac{X}{X+Y}$$

or

$$V_2=V_3+(V_1-V_3)\frac{Y}{X+Y}$$

in which X and Y represent the potentiometer resistances on either side of the grid connection and the effect of the amplifier input impedance Z_2 is considered negligible.

It is often practicable to divide the attenuation change into two components, one of which is constant with frequency and is called the "flat loss", the other being variable with frequency and being called "twist loss". If the equalizer design includes the total attenuation change, the method described herein will compensate for the total change. If the equalizer design includes only that part of the change variable with frequency the method will compensate only for the variable component and it will be necessary to compensate for the flat loss by other means.

The adjustment of the contactor 12 may be made manually. However, if desired it may be made automatically, for example through shaft 17 operated from pilot wire or pilot channel control equipment indicated at 16. For instance, the equipment 16 may be automatic pilot wire transmission regulator control equipment such as that which operates transmission regulating rheostat 12 of the system disclosed in H. S. Black Patent 1,956,547, May 1, 1934, or such as that of Shackleton-Edwards Patent 1,960,350, May 29, 1934; or may be automatic pilot channel transmission regulator control equipment such as that which operates the equalizer-potentiometer 36, 37 of Affel Patent 1,511,013, October 7, 1924 or such as that of R. W. Chesnut Patent 2,049,195, July 28, 1936.

Fig. 1A shows a modification of the portion of Fig. 1 above line B—B, in that there is substituted for the resistance potentiometer 10 a condenser potentiometer 10' comprising fixed condenser plates or armatures 18 and 19 and relatively movable plate or armature 20 cooperating therewith. The impedance of the condenser potentiometer across the equalizer is not independent of frequency but the action of the condenser potentiometer is comparable to that of the resistance potentiometer for voltage dividing purposes, and in the case of automatic operation by equipment 16 the condenser potentiometer has special utility because of its freedom from frictional power losses that would be entailed by employment of a potentiometer having moving electrical contacts.

What is claimed is:

1. A wave translating system comprising a transmission equalizing network for correcting a transmission characteristic, means for supplying input voltage thereto for producing output voltage thereof, a voltage divider, and means for deriving from said network a voltage proportional to the difference between the input and output voltages of said equalizing network and applying said derived voltage to said voltage divider.

2. A wave translating system comprising a network including reactances and having attenuation varying with frequency over a given frequency range, a source of voltage for supplying thereto waves of said range, and attenuating means having substantially uniform attenuation over said range connected to said network for obtaining therefrom a voltage variable smoothly at each frequency of said range by the same proportion of the difference between the input and output voltages thereof.

3. A wave translating system comprising a transmission equalizing network having attenuation varying with frequency, a source of voltage for supplying waves thereto, a two-terminal impedance, and means connecting said network and said impedance for supplying across said two terminals a voltage proportional to the difference between the input and output voltages of said network and giving to each point of said impedance between said two terminals instantaneous potential variable with frequency and of magnitude within the range between the magnitudes of the terminal potentials.

4. The method of adjusting attenuation of a circuit including an attenuation equalizing net-

work whose attenuation varies with frequency over a given frequency range, which comprises supplying to the network waves of the given frequency range, deriving from the network a voltage proportional to the difference between its input and output voltages, attenuating said derived voltage substantially uniformly over the given frequency range, deriving from the output voltage of the network a voltage proportional to the network output voltage, and combining the latter derived voltage and said attenuated voltage, said combined voltage varying with frequency.

5. A wave translating system comprising an equalizing network having attenuation varying with frequency over a given frequency range, a wave source for supplying input voltage thereto and creating output voltage thereof, adjustable attenuating means having substantially uniform attenuation over said frequency range associated with said network for deriving therefrom a variable voltage proportional to the difference between said input and output voltages, and a circuit for combining said derived voltage and said output voltage.

6. A wave translating system comprising a corrective network having a transmission characteristic varying with frequency, means for supplying waves thereto, a potentiometer having an input circuit and an output circuit, means for supplying to said input circuit a voltage proportional to the difference between the input and output voltages of the network, a voltage operated device having an input circuit, and means for connecting said output circuit of said potentiometer in said input circuit of said device.

7. A wave translating system comprising an equalizer network for correcting a transmission characteristic having input terminals and output terminals and having series and shunt impedance arms comprising reactances, with said series arms connected between one of said input terminals and one of said output terminals, a terminating impedance for said equalizer network connected across said output terminals, an outgoing circuit, and variable attenuating means comprising an impedance device connected across said series arms for supplying to said circuit the sum of the voltage across said terminating impedance and an adjustable portion of the voltage between said one input terminal and said one output terminal.

8. A wave translating system comprising an equalizer for correcting a transmission characteristic, a two-terminal impedance, means connecting said equalizer and said impedance for supplying across said two terminals a voltage proportional to the difference between the input and output voltages of the equalizer, and a connection to said impedance between said terminals such that the ratio of the portions of said impedance between said connection and said terminals is adjustable.

9. A wave translating system comprising a network having attenuation varying with frequency, a terminating impedance for said network, a two-terminal impedance, means connecting said network and said two-terminal impedance for supplying across said two terminals a voltage proportional to the difference between the input and output voltages of said network, and a circuit comprising said terminating impedance and connected to one of said terminals and having a connection to said two-terminal impedance dividing said two-terminal impedance into portions whose impedance values are smoothly adjustable.

10. A wave translating system comprising a network having attenuation varying with frequency, a condenser potentiometer, and means for supplying to said potentiometer a voltage proportional to the difference between the input and output voltages of said network.

11. A signaling system comprising a carrier wave transmission line subject to weather changes that vary its attenuation, a repeater and equalizer network therefor, and means comprising a gain control condenser potentiometer connecting said equalizer network with the input of said repeater for compensation of said attenuation variation, said condenser potentiometer having relatively movable condenser armatures, and means responsive to effects of said weather changes for adjusting the relative position of said armatures.

12. The combination of a circuit subject to conditions that change its attenuation and means for compensating for variation, with frequency, of the change of attenuation of said circuit, said means comprising an equalizer network associated with said circuit, a condenser potentiometer having relatively movable armatures, means connecting said network and said potentiometer for supplying to said potentiometer a voltage proportional to the difference between the input and output voltages of said network, and means responsive to effects of said conditions for adjusting said potentiometer.

13. A wave translating system comprising an attenuation equalizer network including reactances and having attenuation varying with frequency over a given frequency range, means for supplying to said network waves of said frequency range, attenuating means having substantially uniform attenuation over said range connected to said network for obtaining from said network a voltage variable smoothly at each frequency of said range by the same proportion of the difference between the input and output voltages of the network, and means for combining effects of said first mentioned voltage and the output voltage of said network.

14. The combination of a network including reactances and having attenuation variable with frequency over a given frequency range, means for supplying thereto waves of said range, attenuating means having substantially uniform attenuation over said range connected to said network for obtaining therefrom a voltage variable smoothly at each frequency of said range by the same proportion of the difference between the input and output voltages of the network, means for adding to the first mentioned voltage the output voltage of the network to obtain a resultant voltage, a voltage operated device, and means for supplying said resultant voltage to said device.

15. The method of equalizing transmission in a circuit including a transmission equalizing network having series and shunt impedance branches containing reactances, which comprises applying a voltage to the input of said network, deriving a voltage from a series branch of the network, deriving a voltage from a shunt branch of the network, adjustably attenuating one of said derived voltages, and combining said other derived voltage and said attenuated voltage to obtain an output voltage such that the transmission loss from said applied voltage to said output voltage is related to the equalizer loss by a factor sub-

stantially independent of frequency but dependent on said adjustable attenuation.

16. The method of adjusting the transmission of a circuit including a transmission control network having reactive series and shunt arms giving the network a transmission characteristic variable with frequency, which comprises applying a voltage to the input of said network, deriving a voltage of given frequency from a selected portion of the series arms of the network, deriving a voltage of like frequency from a selected portion of the shunt arms of the network, adjustably attenuating one of said derived voltages, and combining said other derived voltage and said attenuated voltage to obtain an output voltage such that the transmission loss from said applied voltage to said output voltage is related to the network loss by a factor substantially independent of frequency but dependent on said adjustable attenuation.

17. A wave translating system comprising a transmission line, a transmission equalizing network for correcting a transmission characteristic of said line, said network having input terminals and output terminals and said line supplying voltage to said input terminals, means for terminating said network in its output impedance at its output terminals, means comprising an impedance connected between an input terminal and an output terminal of said network for deriving from said network a voltage equal to any chosen portion of the difference between the input and output voltages of the network, and a circuit for utilizing said derived voltage.

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