

Feb. 11, 1941.

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2,231,538

TRANSMISSION CONTROL

Filed June 21, 1939

2 Sheets-Sheet 1

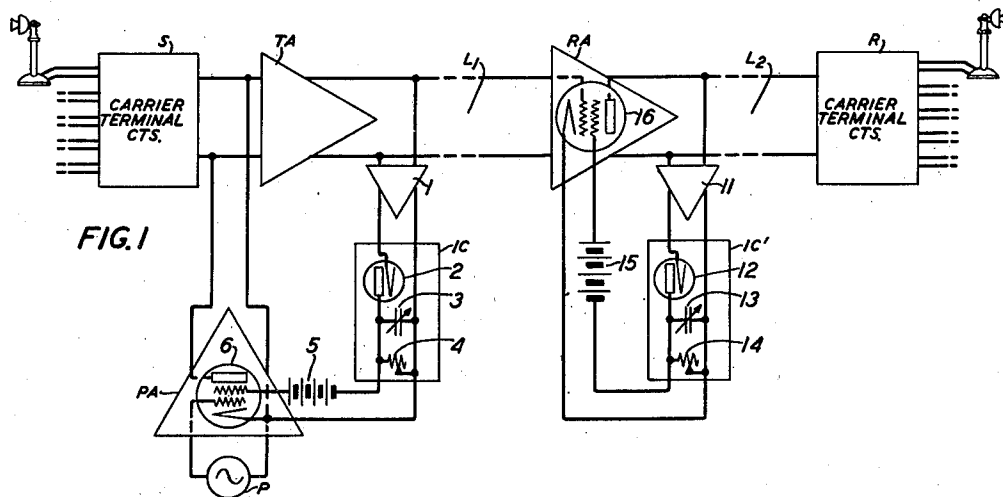


FIG. 1

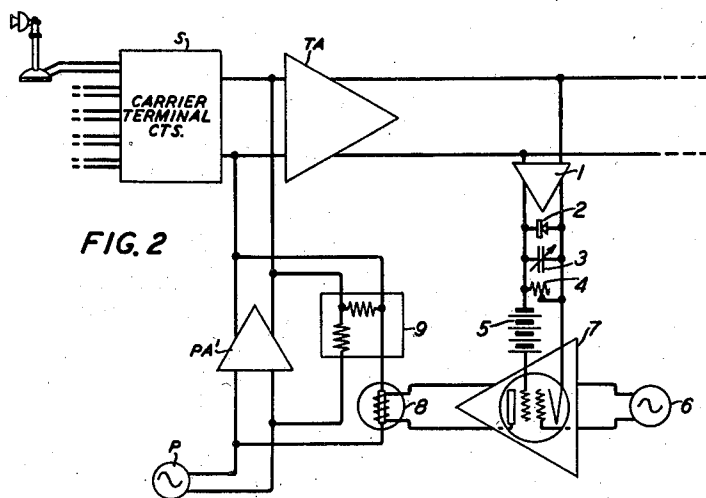


FIG. 2

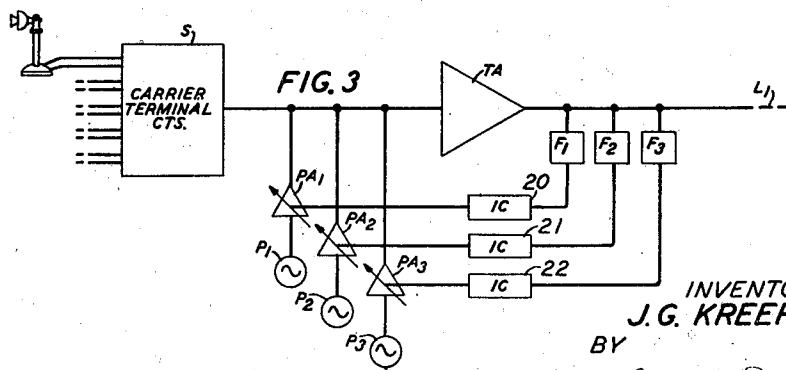


FIG. 3

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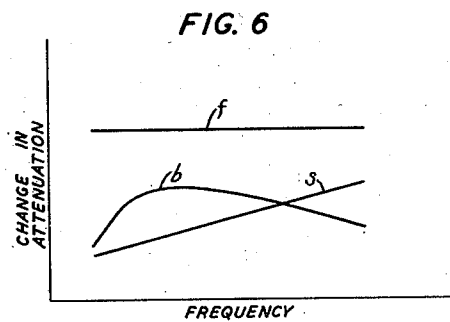
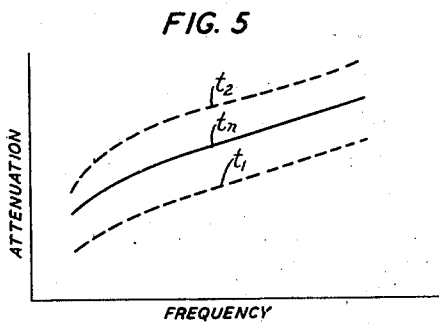
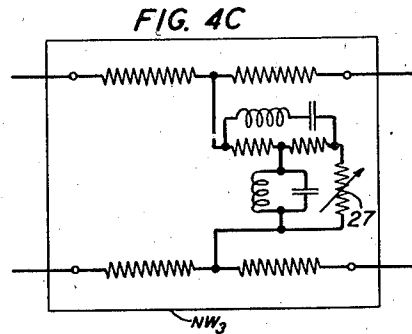
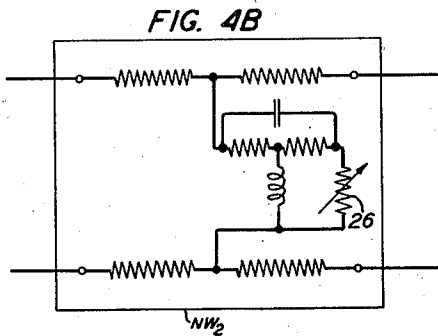
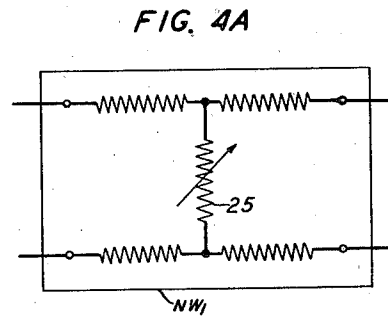
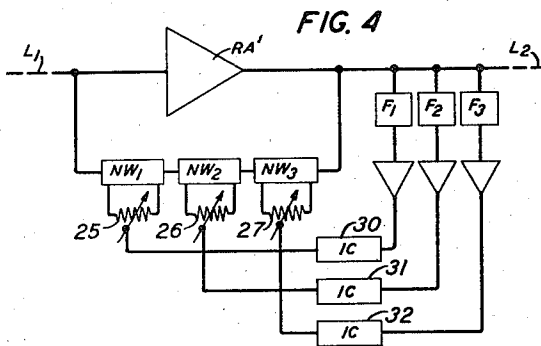
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2 Sheets-Sheet 2



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TRANSMISSION CONTROL

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Application June 21, 1939, Serial No. 230,285

14 Claims. (Cl. 178—44)

The present invention relates to the control of amplification in an electrical system and more particularly to the automatic control of amplification in an electrical signaling system.

5 An object of the invention is to provide new and improved means and methods for controlling the amplification characteristics of an electric wave amplifier. Another object is to so control a receiver of electrical signals as to offset
10 changes in the electrical characteristics of the medium through which the signals are transmitted to the receiver. A more specific object of the invention is to provide new and improved means and methods for effecting automatic and
15 remote control of the transmission characteristics, and more particularly of the amplification, of a repeater in a wire line carrier current signaling system.

20 The present invention is especially applicable to the solution of a problem presented by long distance wire line transmission systems, viz., the problem of automatically adjusting the amplification of signal repeaters in the line so as to compensate precisely the fluctuations in signal intensity that variations in the attenuation of the
25 line tend to produce. Such variations in line attenuation may arise, for example, from changes in the temperature of the line conductors. Although for purposes of exposition the invention
30 will be described principally in terms of its application to the automatic control of amplification in a system of the kind mentioned, the invention and its various features are capable of
35 embodiment in other kinds of systems and the solution of other problems. The broad aspects of the invention will be apparent to those skilled in the art from a consideration of the appended claims.

40 It is well known that in long distance telephone transmission systems the amplification afforded by repeaters in the line must be continually adjusted as the attenuation of the line changes with variations in temperature and other
45 transmission conditions so that the transmission equivalent of each repeater section is maintained within specified narrow limits. Without such adjustment of the "gain" of the repeaters the signal currents would, at least after traversing
50 a large number of repeaters, be amplified to such high power levels as to overload the repeaters and thereby cause intolerable distortion or be attenuated to such lower power levels as to be masked by noise and cross-talk currents. In
55 view of such considerations as these it has been found desirable in practice to maintain the transmission equivalent of each repeater section within a fraction of a decibel of its predetermined normal value.

60 Heretofore it has been proposed that the gain

of the repeaters in a long transmission line be controlled by a "pilot" current of constant initial intensity which is transmitted over the line in a portion of the frequency spectrum not occupied by the signals and which encounters the
5 same variations in line attenuation as do the signals. Whereas the intensity of the signals arriving at each repeater fluctuates with changes in the volume level of the talker's voice as well as with variations in the attenuation of the
10 preceding section of line, it is the latter factor only that affects the intensity of the pilot current. Hence, by automatically adjusting the gain of the repeater under control of the received pilot
15 current so that the intensity of the amplified pilot is continually restored to or maintained at its initial value or at some other predetermined value, the signals are likewise maintained at their initial or some other predetermined
20 transmission level and the transmission equivalent of the repeater section is thus held constant.

In accordance with applicant's invention as embodied in a repeater gain regulating system having important advantages over the system
25 last described, the gain of the repeaters is controlled jointly by the signals and by auxiliary means which compensate for or substantially eliminate the effect of those variations in signal intensity that are not due solely to changes in
30 line attenuation. The auxiliary means in the preferred form comprises means for continuously varying the intensity of a pilot wave in such relation to the normal variations in intensity of the signals applied to the line that the intensity
35 of the signals and pilot wave combined is substantially constant. Each repeater is made so self-adjusting, under the joint control of the signals and pilot wave as amplified by it, that the intensity of the amplified signals and pilot wave
40 combined is maintained substantially constant at its initial value. As the line attenuation changes, the combined intensity of pilot and signal arriving at the repeater changes in the same degree, and the gain change required to restore
45 the combined intensity to its initial value is precisely the gain change required to compensate for the change in signal attenuation. Stated somewhat more broadly, this particular application of the invention involves selection of some
50 parameter of the signals that varies uniquely with whatever variable characteristic of the transmission medium is to be compensated, supplementing the signals with an auxiliary wave of
55 such character that the said parameter of signals and auxiliary wave combined is initially maintained substantially constant, and utilizing the said parameter of the combined waves as it appears at a receiving station to effect a com-
60

pensating adjustment whereby the said parameter is restored to its initial or some other predetermined constant condition.

A feature of the invention in its preferred embodiment is that no filter is required at the repeater station for selecting the pilot wave to the exclusion of the signals, for signals and pilot wave combined are utilized for the control purposes. Another feature is that the combined power available at the repeater for control purposes is so substantial that much less amplification is needed, in some cases none will be required, whereas in other systems utilizing only the power of the pilot wave, a large amount of amplification is required inasmuch as the pilot wave must be of comparatively low intensity to avoid overloading the system during signal power peaks. A further feature is that the control power available at each repeater is automatically maintained at a fixed fraction of the full normal power rating of the repeater amplifier.

The nature of the present invention and other objects, features and advantages will appear more fully in the detailed description of typical embodiments illustrated in the accompanying drawings.

In the drawings:

Fig. 1 shows schematically a wire line signaling system in which an embodiment of the invention is utilized to effect automatic control of signal amplification at repeater stations;

Fig. 2 shows a modified form a circuit for controlling the initial intensity of the pilot wave;

Figs. 3 and 4 show schematically a terminal station and a repeater, respectively, as adapted for more accurate compensation of variations in line attenuation; Figs. 4A, 4B and 4C show circuit details thereof; and

Figs. 5 and 6 are diagrams to which reference will be made in describing Figs. 3 and 4.

Referring now to Fig. 1 there is represented a system for the transmission of signals from a source S on the left to a receiver R on the right through a transmission line which has interposed at intervals therein signal amplifiers the gain of which is to be automatically controlled to offset variations in the attenuation introduced by the transmission line. The signals to be transmitted may be of any character, such as ordinary voice frequency telephone signals, but for purposes of exposition of the invention it will be assumed that the system is a four-wire multiplex carrier telephone system and that the source S provides a multiplicity of carrier telephone signaling channels. Thus there may be, for specific example, twelve carrier telephone channels spaced apart in the frequency range from 12 kilocycles to 60 kilocycles. The total wave output of the source S, whether all signal channels or only some of them are in use and whether or not the respective unmodulated carrier waves are transmitted along with the side-bands, may generically be described as constituting "the signal." After amplification in what may conveniently be referred to as a transmitting amplifier TA the signals are applied to a wire transmission line L₁ through which they are conveyed to the first repeater station.

The repeater includes an amplifier RA which, in a manner to be described, restores the signals to their initial intensity level and thereby offsets the signal attenuation introduced by the line L₁. The amplified signals are then applied to the next section L₂ of the transmission line for trans-

mission to the carrier receiving terminal R. The line section L₂ may include one or more other repeater stations of the kind represented at the end of line L₁. The transmission line may be an open wire line, a pair of conductors in a multipair shielded cable, a pair of coaxial conductors, or any other multiconductor transmission medium, in all of which the attenuation introduced by the line fluctuates as the ambient temperature or the condition of the dielectric medium between conductors changes with the weather.

It has been explained hereinbefore that it is desirable to maintain the transmission equivalent of each repeater section substantially constant despite variations in the attenuation of the transmission line. That is, if signals of a given level are applied to line L₁, for example, the gain of the repeater amplifier RA should be so adjusted automatically that the signal intensity at the proximate end of line L₂ is the same as the initial signal intensity or at least bear some predetermined fixed relation thereto. It is to be noted also that maintaining the signal intensity at the output of repeater amplifier RA substantially constant would afford no solution of the problem inasmuch as the signal intensity depends not only on the attenuation of preceding line L₁ but also on such factors as the speech volume levels of the various talkers and the number of carrier channels in use at any particular time.

In accordance with the present invention, the gain of the repeater amplifier RA is automatically adjusted under the joint control of the signal output of the amplifier and means which compensate for those changes in the signal which are not due substantially solely to line attenuation.

In the embodiment of the invention illustrated in Fig. 1 the aforementioned means comprises a pilot wave generator P which delivers to the repeater amplifier an auxiliary or pilot wave, the initial fluctuations of which are related to those changes in the signal that are not due to variations in line attenuation. Preferably, as shown, the pilot wave is transmitted over the identical line traversed by the signal, and in a portion of the frequency spectrum not occupied by the signal. It may, for example, lie just above the highest carrier channel, in which case, for specific example, it may be supposed that the frequency chosen is about 60 kilocycles per second.

Inasmuch as attenuation is the variable transmission characteristic for which compensation is to be made, the intensity of the signal is a convenient and suitable parameter to utilize in the repeater gain control system. In accordance with the invention then, the same parameter of the pilot wave, viz., its intensity, is caused to fluctuate in such manner that the same parameter of signal and pilot wave combined is maintained substantially constant at the input end of the transmission line L₁.

In Fig. 1 the means for causing the pilot wave intensity to fluctuate in the desired manner is illustrated as comprising a pilot wave amplifier PA of variable gain, through which the pilot wave is applied to the signaling circuit at the input terminals of transmitting amplifier TA. The gain of amplifier PA is then automatically adjusted in response to changes in the intensity of the signal so that the intensity of signal and pilot wave combined is maintained substantially constant. In the preferred form shown in Fig. 75

1 a fixed portion of the pilot wave and signal appearing in the signaling path is diverted from that path, as, for example, at the output terminals of amplifier TA, amplified if necessary in an amplifier 1, and applied to an integrating circuit IC which may be said to measure the intensity of the two combined. The integrating circuit in turn produces a corresponding control voltage or wave which is utilized to effect the required gain changes in amplifier PA.

The nature of the integrating circuit depends on what is to be taken as the measure of intensity. Thus, intensity may be measured in terms of power or root-mean-square value, or in terms of average positive or average negative amplitude as averaged over a predetermined time interval, or in terms of the maximum peak voltage appearing in a predetermined time interval. The specific integrator shown in Fig. 1 comprises a thermionic diode rectifier 2 in series with one of the output leads from amplifier 1, and a condenser 3 and a resistor 4 both shunted across those leads beyond the rectifier. The respective time constants of the charging and discharge circuits of condenser 3, which depend on the capacitance of condenser 3, on the value of resistor 4 and on the forward resistance of rectifier 2, determines the integrating function. If the time constant of the charging circuit is comparatively small and approximately equal to the time constant of the discharge circuit, the voltage appearing across condenser 3 will be substantially proportional to the average amplitude of the applied waves, whereas if the time constant of the discharge circuit is fairly large the voltage developed will be approximately proportional to peak voltage. The time constant of the discharge circuit of condenser 3 controls the sluggishness of the integrator and determines the period over which the applied waves are to be averaged or in which the maximum peak is to be measured. It will be assumed for purposes of further exposition that the elements of the integrator are so proportioned that the control voltage produced by it fluctuates in response to amplitude changes averaged over successive periods of about ten seconds.

The control voltage produced by the integrator is utilized to control the gain of the pilot wave amplifier PA, and for this purpose it may be applied as a variable supplement to a battery 5 which biases a gain-controlling grid of a variable-mu tube in the amplifier PA. The various circuit elements are to be so proportioned that a given change in the intensity of the waves in the input circuit of amplifier TA causes an equal and opposite change in the intensity of the pilot wave delivered by the amplifier PA. It will be noted that when the signal intensity changes there will be or tend to be a corresponding change in the amplitude of the control voltage developed in the integrating circuit, that the change in the latter voltage will cause the gain of amplifier PA and the amplitude of the pilot wave produced by it to change in the opposite sense, so that the average intensity of signals and pilot wave combined tends to remain substantially unchanged.

At the repeater station the signal and pilot wave received from line L₁ are passed through the amplifier RA of variable gain and applied to the outgoing line L₂. A fixed portion of the total wave output of amplifier RA is diverted as at the terminal station, intensified if desired in an amplifier 11 and applied to an integrating circuit IC' comprising elements 12, 13 and 14 corresponding to elements 2, 3 and 4, respectively, of

the integrating circuit at the terminal station. The integrating circuit IC' is designed to utilize the same measure of the intensity of the waves applied to it as is used at the terminal station, which is in the case assumed the average amplitude of the waves as averaged over a period of about ten seconds. The fluctuating unidirectional voltage produced by the repeater integrating circuit is utilized to supplement the biasing effect of battery 15 on the gain of amplifier RA through the medium of a control electrode in the variable-mu vacuum tube 16. The elements of the control circuit are so proportioned that a given percentage change in the voltage developed in the integrating circuit is translated into an equal and opposite percentage change in the gain of the amplifier RA. With the circuit so proportioned the average amplitude of the combined signal and pilot wave at the output of amplifier RA is maintained substantially constant. The sluggishness of the repeater integrating circuit may be the same as that at the terminal station so that one will respond to changes in signal intensity just as rapidly as the other, but this condition is not essential, and in fact it is preferable that the repeater integrating circuit be somewhat slower than the other.

To compensate for variations in the attenuation of line L₂, or of the last line section thereof where that line includes one or more other repeaters, the terminal circuit R may include a self-regulating amplifier of the kind shown for the repeater.

In Fig. 2 is shown a modified form of circuit adapted to introduce the desired variations in the initial amplitude of the pilot wave. The circuit is similar to that shown in Fig. 1, but the pilot wave amplifier PA' is of the negative feedback type in which the gain is determined by the transmission loss in the beta or feedback circuit. The loss elements in the beta circuit comprise a fixed L-type resistor pad 9 and a series resistance which is varied to change the gain of the amplifier. The variable resistor is indicated as a thermistor 8, that is, an element having a high temperature coefficient of resistance, such for specific example, as a filament of silver sulphide or a bead of fused boron or of fused uranium oxide. To control the temperatures of the thermistor, current is derived from a 60-cycle or other low frequency source 6 and applied to a heater winding surrounding the thermistor through a variable gain amplifier 7 which may be of the type PA shown in Fig. 1. The gain of the amplifier 7 is controlled by the combined voltages of battery 5 and the variable voltage produced by the integrating circuit as in Fig. 1. The heating current for thermistor 8 is thus varied in correlation with the average amplitude of the combined signal and pilot wave. The gain of amplifier PA' is similarly correlated with the variations in the resistance of thermistor 8, and by proper correlation of the various circuit elements involved the amplitude of the pilot wave applied to the amplifier TA may be made to vary in the desired relation to the variations in signal amplitude so that the average amplitude of the two combined remains substantially invariable.

If a transmission system is long enough to require several repeaters between the terminal stations it is often desirable to provide more accurate regulation of the gain characteristics of the repeater amplifiers. More particularly, it has been found in practice that when the temperature of the transmission line changes, the change in attenuation is not the same at all fre-

quencies, although to a first approximation it is. To compensate for these second order effects the invention may be extended in a manner to be described with reference to Figs. 3 and 4, which show, respectively, a terminal station and a repeater station incorporating certain additional features of the present invention.

Reference to Figs. 5 and 6 may facilitate an understanding of these additional features of the invention. Fig. 5 shows qualitatively a typical attenuation-frequency characteristic of a transmission line and it indicates the well-known fact that the attenuation is greater at high frequencies than at low. At some predetermined normal or reference temperature t_n the characteristic of the line may be as represented by the solid line. The repeater amplifiers are designed to compensate for this normal characteristic and to restore the transmission level at all frequencies to some predetermined uniform level, and for this purpose the usual fixed equalizing networks may be incorporated in the amplifier. As the temperature of the line changes, however, the attenuation-frequency characteristic of the line changes in shape; and at a low temperature t_1 it may be as represented in exaggerated form by the lower dotted line in Fig. 5, whereas at a high temperature t_2 it may be as indicated qualitatively by the upper dotted line.

The departure from the normal attenuation-frequency characteristic at any given temperature is the effect which the automatic gain regulating system is intended to compensate. This departure may arbitrarily be resolved into three components as represented in exaggerated fashion in Fig. 6. The major component f corresponds to a vertical displacement of the characteristic, uniform over the frequency range, and sometimes referred to as the flat-gain change. It will be obvious that it is only this major component that is compensated in the system illustrated in Fig. 1. The second and comparatively small component s corresponds to a change in the average slope of the attenuation-frequency characteristic. The third component b corresponds to a change in the curvature or "bulge" of the characteristic.

In accordance with the invention, the repeaters in a system of the kind described with reference to Fig. 1, are provided with supplementary networks which are automatically adjusted to compensate respectively for changes in the slope of the characteristic of the preceding line section and for changes in the curvature of that characteristic. More particularly, three auxiliary or pilot waves are transmitted over the system along with the signal and each pilot wave is so varied in initial intensity that three conditions are satisfied: first, one of the pilots, for example that at 60 kilocycles may be varied so that the average intensity of the signal and three pilot waves combined is substantially constant; second, another of the pilots, for example, that at 16 kilocycles may be varied so that the average intensity of the signals and three pilot waves combined, when weighted as to frequency so that certain frequencies are given greater significance in determining the average, is substantially constant; and, third, the remaining pilot, for example that at 28 kilocycles may be varied so that the average intensity of signal and pilot waves combined, when weighted in a different manner as to frequency, is substantially constant. At a repeater station, a portion of the amplified wave output is diverted and means are provided for

obtaining a separate measure of each of the three intensity averages (the one unweighted and the other two differently weighted) of the total wave output of the amplifier. The unweighted measure is utilized to adjust the flat gain of the amplifier so that the unweighted average is restored to or maintained at a predetermined value, such, for example, as the value obtaining at the transmission terminal station. One of the weighted measures is utilized to adjust the slope characteristic of the amplifier and the other to adjust the bulge characteristic of the amplifier so that each of the weighted measures is maintained at a respective predetermined value. When these three conditions are satisfied at the repeater station, the transmission level at the output of the repeater amplifier is constant and substantially uniform at all frequencies, which is the desired condition. It may be noted that it is or may not be necessary in a particular case to provide for correction of all three components at each repeater station. Thus there may be flat gain correction at all repeater stations, slope correction at alternate repeaters and bulge correction at still longer intervals.

Referring now to Fig. 3, the circuit there shown is in general outline the same as the one shown in Fig. 1 except for the provision of three pilot wave sources P_1 , P_2 and P_3 , having respective frequencies of 60, 16 and 28 kilocycles, for specific example, and individual frequency selective control circuits therefor. The latter circuits include the band-pass filters F_1 , F_2 and F_3 each of which diverts from the main signaling circuit a fixed portion of the wave output lying within their respective frequency ranges. Filter F_1 passes all of the pilot waves and signals and introduces no frequency weighting. Hence it may be of simple structure, replaced by a resistance pad or even eliminated. Filter F_2 may have a pass-band centered on the frequency f_2 of pilot wave source P_2 and filter F_3 may have a pass-band centered on the frequency f_3 of source P_3 . Thus the aforementioned unlike frequency weighting is introduced. Each of the integrating circuits 20, 21, 22, is designed with a view to maintaining substantially constant at the output of the transmitting amplifier TA, the average combined amplitude of the corresponding pilot wave and the portion of the signaling wave applied to it.

The integrating circuits may therefore be of the kind shown in Fig. 1. Associated with each of the pilot wave sources is a variable gain amplifier PA_1 , PA_2 , PA_3 , and the gain of each amplifier is controlled in the same manner as the amplifier PA in Fig. 1 by the varying voltage appearing at the output terminals of its individual integrating circuit. It may be noted that the filters F_2 and F_3 need not have sharply selective characteristics, and their transmission bands may overlap to a moderate extent without interfering with the operation of the system. In fact they may be equalizers rather than filters. That is, they may simply have transmission-frequency characteristics that are unlike, especially at the several pilot frequencies.

In the repeater station shown in Fig. 4 the signal and the three pilot waves received from the line L_1 are amplified in the repeater amplifier RA' and applied to the outgoing line L_2 . A portion of the wave output of amplifier RA' is diverted by the respective filters F_1 , F_2 and F_3 , which may be identical with those similarly des-

ignated in Fig. 3. The output of each filter may then be amplified, if necessary, and applied to an individual integrating circuit 30, 31, 32, which again may be the same as the corresponding element in Fig. 3. The variable voltage produced by each of the integrating circuits is then utilized to control the gain-frequency characteristics of the amplifier RA'. One means of exercising the desired control is indicated schematically in Fig. 4 and will now be described.

Preferably, the repeater amplifier RA' is of the negative feedback type in which the gain-frequency characteristic is dependent on the transmission characteristics of the beta circuit. The beta circuit in this case is shown as comprising three functionally separate networks NW₁, NW₂ and NW₃. Each of these networks comprises or is associated with a variable resistor 25, 26, 27 the resistance of which affects the attenuation characteristic introduced into the beta circuit by the respective networks. The amplitude fluctuations of the waves selected by filter F₁ and delivered by its associated integrating circuit 30 are to be translated into corresponding variations in the flat gain of the amplifier, and the network NW₁ is accordingly so constructed and arranged that any change in the resistance of element 25 caused by the control wave is translated into a corresponding change in the attenuation introduced by network NW₁ in the beta circuit of the amplifier. The function of NW₂ is to translate variations in the resistance of element 26, under the control of waves passed by filter F₂, into variations in the slope of the gain characteristic of the amplifier. Similarly, a given amplitude change in the waves passed by filter circuit F₃ means that a certain change has occurred in the curvature of the transmission characteristic and this change in amplitude can be and is translated through changes in the resistance of element 27 associated with network NW₃ into a corresponding variation in the curvature of the attenuation characteristic of the beta circuit.

The three networks represented in Fig. 4 and the means for altering the transmission characteristics in response to changes in the output of the respective integrating circuit may take a wide variety of forms. Where, as suggested, a variable resistance is to effect the change in a transmission characteristic, an indirectly heated thermistor, such as described with reference to Fig. 2, may be employed and its temperature and resistance controlled through a heater winding connected to the integrating circuit. In this case, network NW₁ may take the form of a resistance pad as shown schematically in Fig. 4A with the variable resistance 25 included as a shunt arm of the network. Network NW₂ may have the circuit configuration indicated in Fig. 4B with the variable resistance 26 connected as there shown. Fig. 4B similarly shows a suitable circuit configuration for network NW₃ as well as the manner of connection of the variable resistance 27.

What is claimed is:

1. In a system for signaling between geographically separated stations, the method which comprises transmitting a plurality of discrete signals in respective frequency ranges from one of said stations to the other through a medium that variably attenuates said signals, receiving said signals at said other station, transmitting an auxiliary wave to said other station through a medium subject to like variations in attenuation, varying the initial intensity of said

auxiliary wave in predetermined relation to and under the control of the variations in the integrated initial intensity of all of said signals and under the simultaneous reflexive control of the said varying auxiliary wave, and maintaining the received signals at a predetermined intensity level independent of said variations in attenuation through the joint control of the received signals and auxiliary wave.

2. The method of signaling from one station to a geographically distant station which comprises transmitting a plurality of discrete signals in respective assigned frequency channels from said one station to the other through a medium having a varying transmission characteristic that affects a parameter of said signals, amplifying all of said signals at each of a plurality of repeater points between said stations, receiving said amplified signals at said other station, producing at said one station a control wave that varies in accordance with those variations in said parameter of said signals that appear at said one station so that said parameter of said signals and control wave combined is initially substantially constant and modifying the said signals at each of said repeater points and at said other station under the joint control of all of said signals and said control wave to reduce the effect of variations in said transmission characteristic on said parameter of the signals.

3. The method of signaling from one station to a geographically distant station which comprises transmitting a multiplicity of separate and complete signals in respective carrier wave channels from said one station to the other through a medium which variably affects a parameter of said signals, receiving said signals at said other station, transmitting an auxiliary wave from said one station to said other station through a medium which has a corresponding variable effect on the same parameter of said wave, further varying said same parameter of said auxiliary wave in response to the initial variations in the said parameter of the combined said signals so that said parameter of said signals and auxiliary wave combined is maintained initially substantially constant, and modifying the received signals under the joint control of said signals and auxiliary wave combined to maintain said parameter of the two combined substantially constant.

4. In a system for signaling from one station to another over a wire line that is subject to variations in attenuation, the method which comprises applying signals to said line at said one station for transmission thereover, receiving said signals transmitted over said line at said other station, amplifying said signals at a plurality of spaced points between said stations, transmitting an auxiliary wave from said one station to said other station over a line subject to like variations in attenuation, varying the initial intensity of said auxiliary wave in such manner that the initial intensity of said signals and auxiliary wave combined is substantially constant, and maintaining the intensity of said signals and auxiliary wave combined substantially constant at each of said spaced amplifying points and said other station under the joint control of said signals and auxiliary wave.

5. In a system for signaling from one station to another over a wire line that is subject to variations in attenuation, the method which comprises applying signals to said line at said one station for transmission thereover, receiving said

signals transmitted over said line at said other station, amplifying said signals at a plurality of points of said line intermediate said stations, transmitting an auxiliary wave from said one station to said other station over a line subject to like variations in attenuation, modulating the initial intensity of said auxiliary wave under the control of the average initial intensity of said signals and at each of said intermediate points and said other station varying the average intensity of the received signals, at a rate substantially slower than that of the modulation of said auxiliary wave, under the joint control of said auxiliary wave and said signals.

6. In a system for signaling between geographically separated points, the method which comprises applying signals to a transmission medium connecting said points for transmission there-through, concurrently applying an auxiliary wave to the same medium for transmission along with said signals, deriving an integrated control wave from said signals and said auxiliary wave as applied to said medium and modulating said auxiliary wave with the said control wave.

7. In combination, a signal transmitting station, a geographically distant signal receiving station, a transmission line interconnecting the said stations, means at said stations providing a plurality of carrier wave channels for the transmission of respective complete signals from the one station to the other, means at said transmitting station for impressing a pilot wave on said line, means for deriving an integrated control wave from all of said signals and said pilot wave combined, means for so varying the intensity of said pilot wave under the control of said integrated wave that the average intensity of the signals and pilot wave combined is maintained substantially constant at the sending end of said line, and amplifying means at said receiving station comprising means responsive to the joint control of said signals and pilot wave for maintaining the average intensity of the signals and pilot wave combined substantially constant at the output of said amplifying means.

8. A combination in accordance with claim 7 comprising one or more repeater stations interposed in said line between said transmitting and receiving stations, and means at one or more of said repeater stations responsive to said signals and pilot wave for maintaining the average intensity of the two combined substantially constant.

9. In combination in a signaling system, a source of signals to be transmitted, a generator of substantially single frequency wave for transmission concurrently with said signals, means for rectifying said signals and said waves, and means for modulating the amplitude of said waves in accordance with the rectified output of said rectifying means.

10. A combination in accordance with claim 9 in which said waves are so modulated that said rectified output is maintained substantially constant.

11. In combination in a signaling system, a source of signals, a wire line for the transmission of said signals, means for generating a plurality of pilot waves for concurrent transmission over said line, and means for changing the intensity of said pilot waves in equal and opposite

relation to changes in the average intensity of the same said signals so that at any point in said line the average intensity of said signals and pilot waves combined varies only with changes in the attenuation of said line, signal amplifying means in said line geographically distant from said source, and means controlled by said signals and pilot waves jointly for varying the gain of said amplifying means to compensate for said changes in attenuation.

12. In combination, a source of carrier wave signals occupying a wide frequency range, a transmission line connected to said source for conveying said signals, one or more signal amplifiers geographically distant from said source and connected in tandem relation in said line, means for applying to said line for transmission concurrently with said signals a plurality of auxiliary waves of mutually different frequencies, means for deriving differently weighted measures of the average intensity of said signals and auxiliary waves combined as applied to said line, and means for so modulating each of said auxiliary waves with a respective one of said measures that each of said measures is maintained substantially constant, means at each of one or more of said signal amplifiers for deriving the aforesaid weighted measures of the output of the amplifiers, and means responsive to each of said last-mentioned weighted measures for so adjusting the gain-frequency characteristic of said amplifier that each of said last-mentioned weighted measures is maintained substantially constant, whereby any change in the transmission equivalent of said line is offset by a compensating change in said amplifier or amplifiers.

13. In combination, a transmission line, means for transmitting over said line a multiplicity of distinct signals in respectively different carrier wave signaling channels, means for generating a plurality of substantially single frequency waves for transmission concurrently with said signals, means for amplitude-modulating one of said waves with said signals so that the unweighted average intensity of said signals and waves combined is substantially constant, and means for amplitude-modulating another of said waves so that the average intensity of said signals and waves combined as differently weighted according to frequency is substantially constant.

14. In combination, a source of signals occupying a wide frequency band, means for transmitting said signals through a transmission medium subject to variations in attenuating effect on said signals, means for transmitting along with said signals three pilot waves modulated in predetermined relation to the variations in the average intensity of said signals, and means for amplifying the said signals and pilot waves after transmission through said medium comprising a signal amplifier having respective means for controlling the flat gain, the slope characteristic and the bulge characteristic thereof, operating means responsive to the several controlling means aforesaid and responsive to the unweighted average intensity of the output currents of said amplifier, the average intensity of said currents as weighted according to frequency and the average intensity of said currents as differently weighted according to frequency, respectively.

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