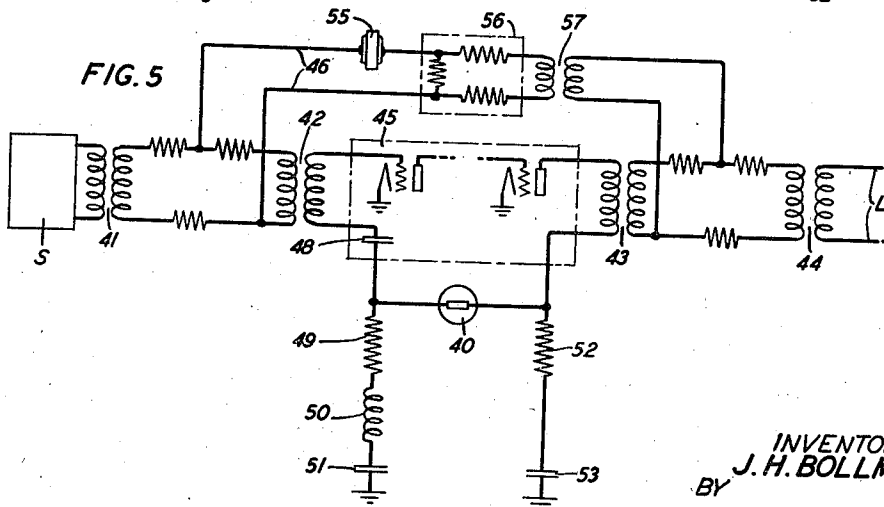
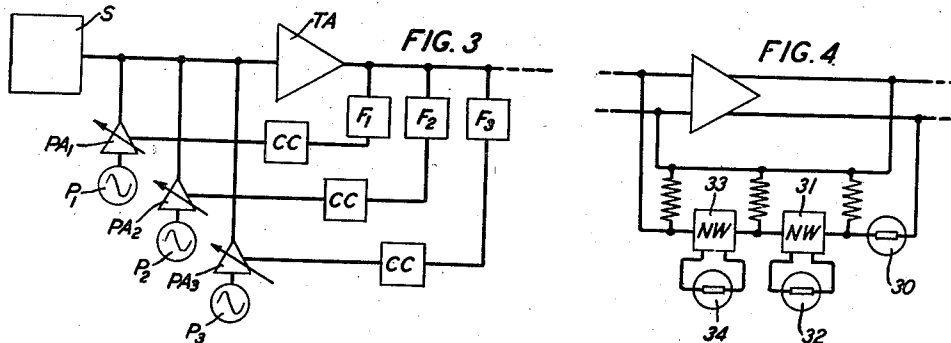
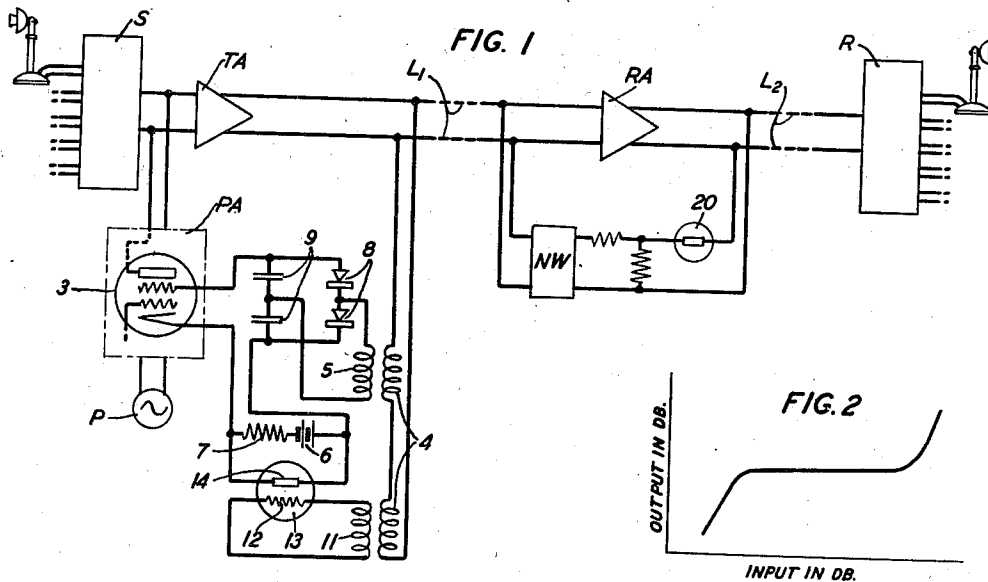


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SIGNAL TRANSMISSION
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SIGNAL TRANSMISSION

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This invention relates to electrical signaling systems and more particularly to the control of amplification in long distance transmission systems.

5 An object of the invention is to effect improved automatic control of the gain of signal amplifiers in a long distance signaling system. Another object is to effect automatically a compensating adjustment in the gain of repeater
10 amplifiers in a wire line transmission system as the line attenuation fluctuates in response to changes in temperature or other factors.

In long wire line signaling systems it has been the practice to provide means for automatically changing the gain of the repeater amplifiers to compensate for fluctuations in the attenuation of the line arising from variations in temperature and in the condition of the dielectric medium separating the conductors. The
20 intensity of the signal arriving at a repeater station affords no measure of the variations in the attenuation of the preceding line section, inasmuch as the initial signal intensity is not fixed but varies with such factors as the speech level of the talker's voice. It has been proposed
25 heretofore, however, that the signal wave be supplemented initially with a pilot wave, lying in a portion of the frequency spectrum not occupied by the signals, which is so varied in amplitude that the average intensity of signal and
30 pilot combined is substantially constant. The average intensity of the two, as received at a repeater station, is then dependent only on the attenuation of the preceding line section, and
35 the repeater amplifier can be made self-adjusting with respect to gain to maintain the two at their initial intensity level or some other suitable predetermined level.

The present invention is importantly featured
40 by new and improved means for producing the variable amplitude pilot wave and by the self-adjusting gain-controlling means provided at the repeater amplifiers whereby the pilot wave and the repeater gain are both controlled in
45 accordance with a power function.

In accordance with a preferred embodiment of the invention, the pilot wave is generated by causing a signal amplifier at the terminal station to oscillate at the desired pilot frequency
50 through a local feedback path. Both pilot wave and signal are applied to a thermistor, which accurately translates their power regardless of the wave form into terms of resistance or some other predetermined function suitable for controlling the gain of the amplifier. The gain-
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controlling circuit operates to maintain the total power output of the amplifier substantially constant so that a change in signal power level automatically produces an equal and opposite change in pilot power level. In another aspect, the gain of the amplifier is held constant and the oscillations of pilot frequency are variably
5 attenuated by a thermistor that is under the joint control of signal output and pilot wave output, so that the sum of the signal output and pilot output remains substantially constant. At
10 each repeater station the total power output of the repeater amplifier is maintained constant at a predetermined power level through a self-adjusting gain control which also comprises a thermistor element to which both signals and
15 pilot waves are applied.

The nature of the present invention and its various objects and features will appear more fully in the following detailed description of the
20 typical embodiments illustrated in the accompanying drawing:

Fig. 1 shows schematically a wire line transmission system embodying certain features of the present invention;

25 Fig. 2 is a diagram to which reference will be made in the description of Fig. 1;

Figs. 3 and 4 show a terminal circuit and a repeater circuit, respectively, for effecting more accurate control of the gain-frequency characteristics of the repeaters; and

Fig. 5 shows schematically a preferred form of pilot wave generator in accordance with the invention.

Referring now to Fig. 1, there is represented
35 a system for the transmission of signals from a source S on the left to a receiver R on the right through the medium of a wire line that has one or more signal repeaters therein. The signals may be of substantially any character,
40 but it will be assumed for purposes of exposition of the invention that the source S represents the transmitting terminal circuits of a multiplex carrier telephone system providing, for specific example, twelve carrier channels
45 spaced apart in the frequency range from 12 to 60 kilocycles per second. The total wave output of the source S, regardless of the number of channels in use at any particular time, constitutes "the signal." The signal receiver R,
50 in the specific example assumed, represents the receiving terminal circuits of the system and it may be adapted to separate the carrier telephone signals received and translate them into individual voice frequency circuits. A dupli-
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cate system may be provided for transmission of signals in the opposite direction.

The transmission medium is represented as being a wire line and it may take any of a variety of forms, such as an open-wire line, a pair of coaxial conductors, or a pair of conductors in a multipair shielded cable. In all of these cases the attenuation suffered by the signal tends to vary, for changes in the ambient temperature affect the resistance of the conductors, and rain and ice, for example, further affect the attenuation of exposed lines. To compensate for such changes in attenuation and to maintain the transmission equivalent of the system constant despite such changes is one of the objects of the present invention. It should be borne in mind, however, that the invention has application also to radio transmission systems, where the ether constitutes the transmission medium and fading and like effects give rise to variable attenuation of the radio frequency signals.

In general outline the specific embodiment of the invention illustrated in Fig. 1 involves the generation of an auxiliary or pilot wave of varying amplitude at the transmitting terminal station, concurrent transmission of pilot wave and signal over the line to the receiving terminal station, and automatic regulation of the gain of the repeater amplifiers under the joint control of pilot wave and signal. More particularly, the pilot wave is caused initially to fluctuate in intensity in such relation to the normal fluctuations in the intensity of the signal that the power of signal and pilot wave combined is maintained substantially constant at the point where the two are applied to the first section L_1 of the transmission line. At the first repeater station the two are amplified in the repeater amplifier RA and the gain of the latter is automatically adjusted under the control of the total wave power output therefrom in such manner that the total wave power output is maintained substantially constant, independent of variations in the wave power applied to it, at some predetermined level, as, for example, the constant power level obtaining at the input end of line section L_1 . From the first repeater station, the waves are transmitted over another section L_2 of the line, which may include other repeaters of the self-regulating type described, and eventually to the receiving terminal station R which also may include a self-regulating amplifier of the same type to compensate for the variable attenuation of the line section next preceding it.

The pilot wave may lie in any suitable portion of the frequency range not occupied by the signal channels and either within or outside the 12 to 60 kilocycle signaling range, but the frequency should be such that any change in line attenuation at that frequency is approximately the same as the corresponding average change in attenuation over the signaling range. In a typical case where the line comprises a multipair shielded cable, a pilot frequency of 61 kilocycles per second may be found to satisfy this requirement.

The pilot wave is derived from a constant frequency constant amplitude source P at the transmitting terminal station, as illustrated in Fig. 1, passed through a pilot wave amplifier PA and applied to the main signaling path along with the signal from source S. Both signal and pilot wave are concurrently amplified in

what may be called a transmitting amplifier TA of fixed gain before they are applied to the line L_1 . The desired initial variation in the intensity of the pilot wave is effected by varying the gain of the pilot wave amplifier PA, as by varying the bias applied to a gain-controlling grid of a variable mu tube 3 in that amplifier, in response to changes in the total power of signal and pilot wave combined as the total power appears, for example, in the output circuit of transmitting amplifier TA. For this purpose a fixed portion of the wave power output of amplifier TA is diverted to the primary winding 4 of a three-winding transformer connected across the output circuit of that amplifier. One secondary winding 5 of the transformer is connected to the input terminals of a voltage-doubling half-wave rectifier comprising a pair of copper oxide rectifier units 8 and a pair of condensers 9. One output terminal of the rectifier is connected directly to the gain-controlling grid of the variable mu tube 3, and the other output terminal is connected through battery 6 and series resistor 7 to the cathode of that tube. The other secondary winding 11 is connected across the heater element 12 of an indirectly heated thermistor unit 13, and the thermistor 14 itself is shunted across the series combination of battery 6 and resistor 7. The thermistor 14 is a resistance element having a high temperature coefficient of resistance, of which filamentary silver sulphide is a familiar typical example, and of which beads of uranium oxide and of boron are other examples. In the operation of the circuit described, there is applied to the gain-controlling grid a control voltage comprising a small fluctuating unidirectional voltage component from the rectifier and another fluctuating voltage component due to the battery 6. The net control voltage applied is dependent principally on the shunting effect of thermistor 14, which, in turn, depends on the heat generated in, and the wave power applied to, heater 12.

Thus, the control voltage depends on the intensity of the wave output of the amplifier TA, being a function of the average amplitude and the average power combined of that wave output. By proper proportioning of the various circuit elements, the power of the wave output of amplifier TA can be maintained substantially constant, so that a given change in signal power is accompanied by an equal and opposite change in the power of the pilot wave.

The resistance of thermistor 14 cannot change instantaneously with changes in the power applied to it, and if it is very sluggish in this respect a sudden increase in signal intensity may not give the thermistor time to change resistance and to reduce the intensity of the pilot wave sufficiently to avoid overloading of the transmitting amplifier TA. A feature of the circuit shown in Fig. 1 avoids this possible difficulty, however, for the rectifier circuit responds substantially instantaneously to changes in signal intensity and of itself effects immediately a reduction in the gain of amplifier PA and a corresponding reduction in the intensity of the pilot wave. In due course the thermistor assumes the proper temperature and resistance and it resumes its proper function of controlling the gain of the pilot wave amplifier.

The repeater is illustrated, purely schematically, in Fig. 1 as comprising an amplifier RA of the stabilized negative feedback type, in which the gain-frequency characteristic is determined

by the gain-attenuation characteristic of the feedback or beta circuit. The beta circuit includes the usual phase shifting, equalizer and other circuits, represented by the network NW, which give the amplifier a rising gain-frequency characteristic such as to compensate for the "normal" attenuation characteristic of the preceding line section L₁. Included also in the beta circuit is a T-type resistance pad one series arm of which comprises a self-heated thermistor 20 that normally receives a fixed fractional portion of the wave power output of the amplifier. If the power output of the amplifier should tend, say, to increase, as by reason of a temporary reduction in the attenuation of the line L₁, the temperature of the thermistor would tend to rise and its resistance to fall thereby tending to reduce the beta circuit attenuation, to decrease the gain of the amplifier and to reduce the wave power output of the amplifier. The thermistor and the other arms of the resistance pad may readily be proportioned so that for a wide range of variation of the input power to the amplifier the output power remains substantially constant.

Fig. 2 shows qualitatively the relation between the wave power applied to the input circuit of the repeater amplifier RA and the wave power appearing in its output circuit. The operating range falls within the horizontal portion of the curve representing substantially constant power output.

Whereas the system illustrated in Fig. 1 is adapted to compensate for changes in the average attenuation of the line over the signaling frequency range, Figs. 3 and 4 show schematically an extension of the invention adapted to compensate also for changes in the shape of the attenuation-frequency characteristic of the line due, for example, to changes in temperature. It is known that, as the temperature of a line changes, the primary effect is a change in attenuation that is substantially uniform over the frequency range, but that there are also secondary effects which may be resolved into a change in the slope or "tilt" of the characteristic and a change in the curvature or "bulge." The primary effect is corrected in Figs. 3 and 4 by substantially the same means employed in Fig. 1. The two secondary effects are corrected by providing two additional amplitude-modulated pilot waves and respective means in the repeater amplifier for automatically adjusting the gain-frequency characteristic of the amplifier. The two additional pilot waves are differently modulated in such manner that the average intensity of the wave output of the transmitting amplifier TA, when weighted in two different manners according to frequency, is maintained substantially constant. At the repeater the gain characteristic of the repeater amplifier is automatically varied so that the two weighted intensity averages, as observed at the output of the repeater, are also maintained substantially constant.

Referring now to Fig. 3, which shows the apparatus and circuits at the transmitting terminal, three pilot wave sources, P₁, P₂, P₃, are provided, each connected through a respective variable gain amplifier, PA₁, PA₂, PA₃, to the input circuit of the transmitting amplifier TA. Across the output circuit of the latter are connected three devices, F₁, F₂, F₃, each of which diverts a fixed portion of the wave output of the amplifier, and each of which is connected to a respective control device CC that is adapted to obtain a measure of the average intensity of the

waves applied to it. The several measures thus derived are then utilized to control the gain of the respective pilot wave amplifiers. The latter and the control devices CC may be identical with the correspondingly functioning elements in Fig. 1. Assuming that pilot wave source P₁ is to be associated with the flat gain controlling function, the device F₁ should be designed to introduce no frequency weighting, that is, to transmit all frequencies applied to it without discrimination. Device F₂ should have a non-uniform transmission-frequency characteristic so as to introduce frequency weighting; device F₃ should have a different frequency weighting characteristic. By proper proportioning of the various circuit elements, the average intensity of the wave output of amplifier TA can be maintained substantially constant, not only as regards the unweighted average but also with respect to the average as determined after weighting in the manner provided by devices F₂ and F₃, respectively.

A repeater amplifier suitable for cooperation with the terminal apparatus of Fig. 3 is shown diagrammatically in Fig. 4. The amplifier is of the negative feedback type and its amplification characteristic is determined by the attenuation characteristic of its beta circuit. The beta circuit includes, as illustrated, a series thermistor 30 of the self-heated type which functions as the thermistor 20 in Fig. 1 to control the flat gain of the amplifier. Instead of the single network provided in Fig. 1, two networks, 31 and 33, are included in the beta circuit and separated from each other and the thermistor by shunt resistors. Connected in operative relation to each of the two networks is a respective thermistor 32, 34, of the self-heating type, which is supplied with current from the beta circuit and which modifies the beta circuit characteristics of its associated network as its temperature and resistance change. By appropriate design of the networks, the heating current supplied to each of the thermistors 32, 34 can readily be weighted in accordance with the same weighting function as is introduced by a respective corresponding one of the devices F₂, F₃ at the terminal station. By further appropriate design, any change in the resistance of, say, thermistor 32, can be translated through the network 31 into a change in the tilt of the gain characteristic of the amplifier such that the output of the amplifier weighted in accordance with network 31 tends to be maintained substantially constant. Similarly, any change in the resistance of thermistor 34 can be translated through network 33 into a change in the bulge of the gain characteristic whereby the output of the amplifier weighted in accordance with network 32 tends to be stabilized. With the networks thus designed, any change in the tilt or bulge characteristics of the transmission line tends to introduce a corresponding change in one or the other of the weighted intensity averages at the input of the repeater station, which tendency gives rise to an opposing or compensating change in the gain characteristic of the amplifier.

Fig. 5 shows a preferred embodiment of the present invention as adapted and applied to the production of a fluctuating wave of the kind required for the system shown in Fig. 1. The signal source S in Fig. 5 corresponds to the signal source in Fig. 1. Between the source and the outgoing transmission line L₁ there is interposed a signal amplifier for which two feedback paths, or beta circuits, are provided. The one path

provides negative feedback and constitutes the amplifier a stabilized negative feedback amplifier having substantially equal gain over the frequency range occupied by the signal to be amplified. The other path provides positive feedback over a relatively narrow band of frequencies and allows the generation of self-sustaining oscillations at the desired pilot frequency. The amplifier includes a thermistor which is heated by the signal current and the locally generated oscillations and which operates to so vary the intensity of those oscillations that a change in the power content of the signal gives rise to an equal and opposite change in the power of the pilot frequency oscillations whereby the total power output of signal and pilot combined is held substantially constant.

More specifically, as it appears in Fig. 5, the input circuit of the amplifier includes a pair of tandem connected transformers 41, 42 constituting a bridge circuit to which one end of the positive beta circuit 46 is connected and the output circuit includes a similar pair of tandem connected transformers 43, 44 to which the other end of the positive beta circuit is connected. Between each pair of transformers there are connected series resistors which are so proportioned in known manner in relation to the points of connection of circuit 46 that the latter circuit is in conjugate relation to the source S and to the line L₁ but in energy transfer relation with the circuit connecting transformers 42 and 43. A multistage amplifier section 45, of which only the first and last stages are indicated, is interposed between the transformers last mentioned. The amplifier may be of any suitable type adapted for stabilized negative feedback operation. The amplifier shown is of a usual type in which specifically one secondary terminal of transformer 42 is connected to the grid of the vacuum tube in the first stage; the other secondary terminal is connected through a blocking condenser 48, a resistor 49, inductance 50, and blocking condenser 51 to ground, which is the potential of the cathodes of the several amplifier tubes; one primary terminal of transformer 43 is connected to the anode of the vacuum tube in the last stage and the other primary terminal is connected through resistor 52 and condenser 53 to ground; and a connection comprising resistance device 40 extends between the respective high potential ends of resistors 49 and 52. The device 40 and the several elements 48 to 53 are so proportioned as to constitute an output circuit bridge and negative feedback circuit such that the signal amplifier has substantially uniform gain over the frequency range occupied by the signal and the pilot wave.

The details of the negative feedback circuit are relatively unimportant to the principal objects of the present invention excepting for the resistance device 40 and its operation. This is a thermistor of the self-heating type so that its resistance is a function of the heating effect of the current traversing it. It may be enclosed in a heat insulated chamber and provided otherwise with means for insulating it from or compensating for the effect of variations in the ambient temperature. The thermistor 40 is assumed to have a negative temperature coefficient of resistance as does, for example, filamentary silver sulphide or a bead of boron, so that by its series connection in the negative feedback circuit it tends to reduce the attenuation of the feedback circuit, thereby decreasing the over-all

gain of the amplifier, if the currents traversing it tend to increase as by reason of an increase in the wave power output of the amplifier. Conversely, if the wave power in the output circuit of the amplifier tends to decrease thereby decreasing the amount of power diverted to the negative feedback circuit through the output circuit bridge, the temperature of thermistor 40 tends to fall and its resistance to increase, this effect in turn tending to increase the attenuation of the negative feedback circuit, to decrease the amount of wave power fed back in negative phase relation to the input circuit, and to increase the net gain of the amplifier. The consequence in either case is that the thermistor 40 operates to oppose or reduce the extent of any change in the wave power in the output circuit of the amplifier. By proper proportioning of the characteristics of thermistor 40, in fact, the wave power output of the amplifier readily may be, and is, held substantially constant.

The positive feedback circuit 46 includes a device, such as a piezoelectric crystal 55, which blocks or substantially impedes the transmission through that circuit of waves of all frequencies excepting the frequency of the desired pilot wave. In the same feedback circuit, but nearer the output circuit of the amplifier, is a balanced resistance pad or attenuator 56 and a transformer 57. The latter is merely representative of whatever phase shifting means, if any, may be required to insure that the circuit 46 functions as a positive feedback circuit.

Considering the "positive" mu-beta loop comprising the crystal 55, and supposing that there is no signal from source S, it is evident that oscillations will tend to appear in this loop at the substantially single frequency passed by the crystal if there is a net circuit gain around this loop, that is, if at that frequency the gain in the mu circuit of the amplifier exceeds the loss in the beta circuit, which loss is substantially that of the pad 56. Once oscillations appear they tend to increase indefinitely in intensity, but as they do the fixed portion of the oscillatory power diverted to the negative feedback circuit likewise increases, the temperature of thermistor 40 is thereby raised and its resistance reduced. Consequently, the attenuation of the negative feedback circuit is reduced thereby permitting a greater proportion of the oscillations to be transmitted through it and combined in phase opposition with the oscillations from circuit 45. The tendency described will continue to the point where the attenuation of the two feedback paths is alike, for then if a voltage is applied from any source to the mu circuit it will continue to cause current to flow with unchanged amplitude when the source is removed.

From a different point of view one may note the relation of the mu circuit and the negative feedback path on the one hand, treated as constituting together a negative feedback amplifier in which the over-all gain is equal to the attenuation of the negative feedback path, and the positive feedback circuit on the other hand. The negative feedback amplifier as thus constituted has the characteristic that the gain varies with the intensity of the waves applied to it in such manner that the total wave power output is held substantially constant at some predeterminable value dependent on the proportioning of the circuit elements. In loop relation with the amplifier is the positive feedback circuit comprising crystal 55, and oscillations build up in this loop

until at the output of the amplifier the oscillation power reaches the aforesaid predeterminable value and thereafter remains constant. At this point the gain of the negative feedback amplifier is equal to the loss of the positive feedback circuit and there is zero net gain around the loop.

The circuit illustrated in Fig. 5, as above described, constitutes an oscillator having a power output that is constant and that is fixed by the characteristics of the thermistor in the negative feedback loop.

When a signal is applied to the input terminals of the amplifier in Fig. 5 it is amplified and then finds its way into the two feedback circuits. In the positive feedback circuit it is stopped, or substantially so, inasmuch as the crystal 45 will pass at most only a very narrow range of frequencies. In the negative feedback circuit, the amplified signal tends to raise the temperature of thermistor 40 and thereby to reduce the attenuation of that feedback circuit and to decrease the overall gain of the amplifier. Accompanying this tendency is the tendency of the intensity of the locally generated oscillations and their heating effect on thermistor 40 to decrease with the decrease in the over-all gain of the amplifier. The equilibrium condition is finally reached at which the total power output of the amplifier, signal plus local oscillations combined, is substantially constant at the original power output level, the thermistor is at its original temperature and resistance value, and the gain of the amplifier is at its original value and equal to the loss in the positive feedback circuit, at least at the frequency of the local oscillations. The net result is that at any point in the negative mu-beta loop as well as at the output terminals of the amplifier the change in the power of the local oscillations is equal and opposite to the change in signal power so that the power of signal and local oscillations combined remains constant. The locally generated oscillations therefore constitute a signal-modulated wave suitable for use as the pilot wave required in Fig. 1.

From the point of view first adopted in describing the operation of Fig. 5, it may be noted that introduction of the signal tends to reduce the attenuation of the negative feedback circuit and to allow a greater proportion of the local oscillation to flow through that circuit and be combined in phase opposition with the oscillations from the positive feedback circuit, thereby tending to reduce the local oscillations.

It may be noted that the circuit shown in Fig. 5 constitutes also a pure product modulator, in which the locally generated oscillations have impressed on them power fluctuations corresponding to the signal. The effectiveness of the combination as a modulator depends on the rapidity of the signal fluctuations and the sluggishness in the response of the thermistor to changes in applied power. A fast operating thermistor and a comparatively low frequency signal permit the greatest effectiveness. It may be noted also that the circuit embodies an amplifier of variable gain in which the gain is controlled by oscillations of adjustable intensity, or power, specifically, affecting the attenuation of a negative feedback circuit, or, more particularly, one in which the gain is fixed by and equal to the loss in a positive feedback circuit.

For regulating the gain of a wire line transmission system it is not essential that the thermistor maintain the total wave power at a constant value at every instant inasmuch as the

changes which the regulating system is designed to compensate may be and ordinarily are comparatively gradual changes. It will usually be entirely sufficient therefore that the sluggishness, thermal inertia, or lag of the thermistor 40 be such as to recognize and compensate for changes in the average heating current appearing in successive ten-second intervals, for example. Preferably, however, the thermal lag is small enough that the thermistor resistance follows the variations in signal power that occur from syllable to syllable or at equivalent frequency. When substituting the terminal circuit shown in Fig. 5 for that in Fig. 1, it is desirable that the thermistor in the repeater circuit be made at least as sluggish as that in the terminal circuit so that the repeater will be substantially non-responsive to such minor variations in wave power as the terminal circuit may permit to appear on the line.

Although the present invention has been described with relation to various specific applications and embodiments thereof, it is evident that the various novel features are capable of other embodiments and of use for other purposes within the scope and spirit of the appended claims.

What is claimed is:

1. In combination, a source of signals of variable average power content, means for amplifying the signals from said source, a feedback path local to said amplifying means for generating therein substantially single frequency oscillations, and means for changing the power of said oscillations in equal and opposite relation to changes in the average power of said signals, whereby the total output power content of the two combined is maintained substantially constant.

2. In combination, a source of signals of variable average power content, means for amplifying the signals from said source, a feedback path local to said amplifying means for generating therein substantially single frequency oscillations, a thermistor connected in such relation to said feedback path as to variably control the amplitude of said oscillations, and means for applying heating power to said thermistor in proportion to the total wave power output of said amplifying means.

3. In combination, a source of signals of variable average intensity, an amplifier connected thereto having two mu-beta loops, one of said loops providing negative feedback over the frequency range of said signals, and the other of said loops providing positive feedback, the transmission-frequency characteristics of said loops being so proportioned that substantially single frequency oscillations appear in said other loop within the frequency range of said one loop, a thermistor connected to introduce a variable transmission loss in said one loop, and means for heating said thermistor in proportion to the total output power of said oscillations and said signals.

4. A combination in accordance with claim 3 in which said thermistor is so proportioned and arranged in said one loop that the said total output power is maintained substantially constant.

5. In combination, a source of signals of variable intensity, an amplifier connected thereto having two mu-beta loops, one of said loops providing negative feedback over the frequency range of said signals and the other of said loops providing positive feedback of such magnitude over at least a narrow frequency range that oscillations

tions are generated in said other loop within said narrow frequency range, a variable transmission controlling element in one of said loops, said element being controlled in accordance with the total wave power output of said amplifier.

5 6. A combination in accordance with claim 5 in which said element is a thermistor.

7. In combination, a source of electric signals of varying intensity, an amplifier connected thereto having a positive feedback circuit and a negative feedback circuit, said negative feedback circuit having a transmission band embracing the frequency range occupied by said signals, said positive feedback circuit having a narrow transmission frequency band such that oscillations are generated therein within said transmission band of said negative feedback circuit, a self-heating thermistor connected in amplifier gain-controlling relation in said negative feedback circuit, said feedback circuits and said thermistor being so proportioned that the total wave power output of said amplifier, comprising said signals and said oscillations, is maintained substantially constant.

25 8. In combination, an amplifier, a negative feedback circuit and a positive feedback circuit for said amplifier, means inhibiting oscillations in said positive feedback circuit except over a narrow frequency range, and resistance means in said negative feedback circuit variably controlled by said oscillations for stabilizing said oscillations.

9. An oscillatory system comprising an amplifier having a negative feedback circuit, a positive feedback circuit, transmission means in said positive feedback circuit selectively passing only a narrow range of frequencies, and a thermistor for controlling the amplitude of oscillations traversing said positive feedback circuit, said thermistor being operatively connected in the mu-beta loop comprising said negative feedback circuit.

10. A system in accordance with claim 9 in which said thermistor is connected in gain-con-

trolling relation in said negative feedback circuit.

11. In combination, an electric wave amplifier having input and output circuits, a positive feedback circuit local to said amplifier for generating oscillations, a source of electric waves, and means for modulating said oscillations with said waves comprising a connection from said source to the input circuit of said amplifier and means for regulating the total wave intensity appearing in said output circuit.

12. In combination, an electric wave amplifier, a local oscillatory transmission loop comprising said amplifier, means for applying signals to said amplifier for transmission therethrough and means continuously maintaining the total wave power output of said amplifier substantially constant, said output comprising said signals and the oscillations generated in said loop.

13. A combination in accordance with claim 20 in which said last-mentioned means comprises a thermistor heated by said signals and said oscillations.

14. In a system for the transmission of signals of normally varying power content from a sending station to a geographically distant receiving station through a transmission medium that variably attenuates said signals, the method which comprises transmitting a pilot wave concurrently with said signals from said sending station to said receiving station, varying the amplitude of said pilot wave so that the average total power content of said signals and pilot wave combined is maintained substantially constant at said sending station, and at said receiving station amplifying said signals and pilot wave and varying the amplification under the joint control of said signals and pilot wave so that the average total power content of the two combined is maintained substantially constant, whereby the variable attenuation of said transmission medium is compensated.

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