July 14, 1936. C. S. DEMAREST 2,047,312

SIGNALING SYSTEM

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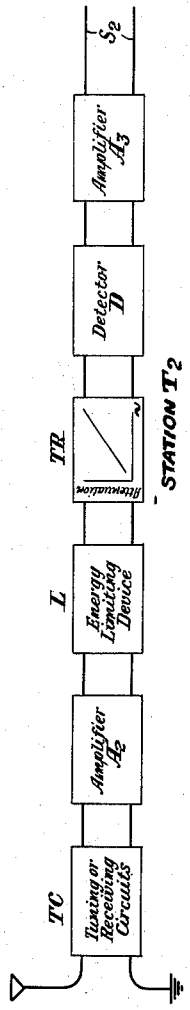


Fig. 1

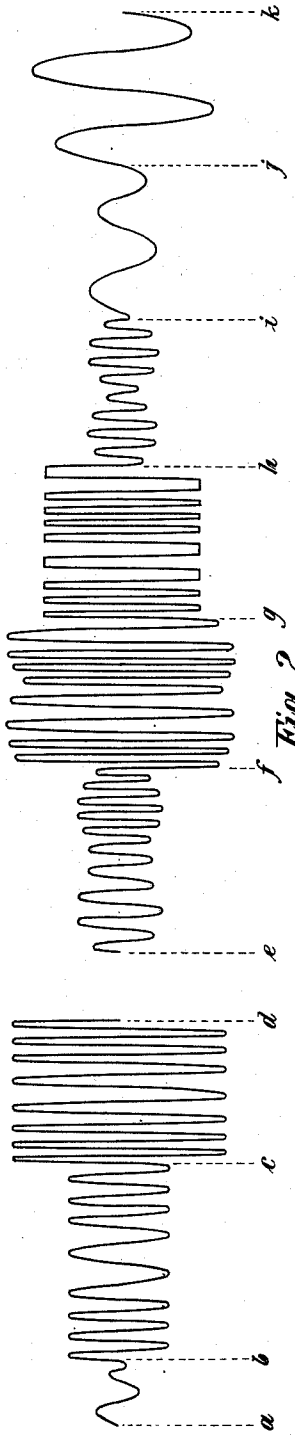


Fig. 2

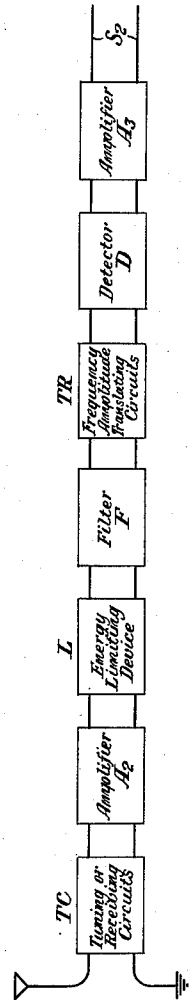


Fig. 3

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SIGNALING SYSTEM

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13 Claims. (Cl. 250—6)

This invention relates to signaling systems, and particularly to a signaling system in which a carrier current is modulated as to frequency in accordance with signaling currents at the transmitting station of the system and in which the frequency modulated carrier current is retranslated into the original signaling currents at the receiving station of the system.

When a carrier current is modulated as to frequency in accordance with signaling currents and is transmitted through a medium of varying attenuation, as in the case of radio transmission, or in the case of transmission over a wire circuit having variable leakage to ground, or having a variable resistance, the carrier current modulated as to frequency is received at the receiving station of the system with varying amplitude due to the varying attenuation characteristic of the transmitting medium. This effect of the transmitting medium on the carrier current is known as "fading." At the receiving station of the system, upon conversion of the carrier current modulated as to frequency into the signaling currents, it is found that the signaling currents become distorted by virtue of the fact that the carrier current is received, not only modulated as to frequency but modulated also as to amplitude, having passed through a medium of varying attenuation.

Accordingly, it is an object of this invention to provide a signaling system employing frequency modulation as a means for the transmission of signals, which will be substantially free from the effects of fading, due to the passage of the frequency modulated currents through a medium of varying attenuation.

It is another object of this invention to amplify a carrier current modulated as to frequency in accordance with signals, and further modulated as to amplitude due to the varying attenuation properties of a transmitting medium, to such a level that when passed through a power-limiting device, the amplitude variations of the carrier current will be effectively nullified so that the carrier current modulated as to frequency alone may be converted into current of varying amplitude which may be detected by a detecting device, in order that the signaling currents may be reproduced.

It is another object of this invention to pass current modulated as to frequency within definite limits and further modulated as to amplitude, through an energy-limiting device to limit the energy transmitted to a definite value so as to render the amplitude modulations ineffective, and then to pass the current through a filter which freely passes currents of frequencies within the range of variation of the frequency-modulated current in order to substantially suppress harmonics and other extraneous frequencies introduced by the energy-limiting device.

While the invention will be pointed out with particularity in the appended claims, the invention itself, both as to its further objects and features, will be better understood from the detailed description hereinafter following, when read in connection with the accompanying drawing, in which Figure 1 represents a signaling system characteristic of the invention employing frequency modulation throughout; Fig. 2 shows the current characteristics at different stages throughout the signaling system; and Fig. 3 represents one form of receiving system which may be employed to carry out the principles of this invention.

Referring to Fig. 1 of the drawing, there is shown a signaling system comprising a transmitting station T_1 and a receiving station T_2, which are a considerable distance apart, the transmitting station T_1 transmitting through its antenna radio waves which are received by the antenna at the receiving station T_2. The reference character S_1 designates a line over which signaling currents pass to a modulator M. An oscillator O is also connected to the modulator M. This oscillator may be of any well-known type and is preferably of a vacuum tube type sustaining oscillations of a definite frequency which may be varied by means of the modulator M in accordance with the signaling currents passing over the line S_1. The modulator M transmits a current of substantially uniform amplitude, which is modulated as to frequency in accordance with the amplitude variations of the signaling currents passing over the line S_1. The modulator M might have some such amplitude-frequency conversion characteristic as is represented by the curve drawn on the rectangle of the modulator, effecting variations in the transmitted frequency corresponding to the amplitude variations of the signaling currents. If the modulator has the transmission characteristic shown, the frequency of the transmitted current will increase as the amplitude of the signaling currents increases, and vice versa. Moreover, under the assumed condition the frequency of the current transmitted by the modulator M will vary uniformly with uniform amplitude variations in the signaling currents. Yet it is to be understood that the modulator M might have any other well known transmission charac-

teristic within the scope of this invention. It is to be further understood that any well-known frequency-modulating system might be employed herein within the scope of this invention, the only condition being that the current transmitted by the system shall vary in frequency in accordance with amplitude variations of the signaling currents.

The frequency modulated carrier current transmitted by the modulator M passes through an amplifier A_1 which amplifies the current to a level suitable for transmission. This amplifier may be of any well-known type, preferably of any vacuum tube type well known in the art. The antenna at the transmitting station T_1 transmits the frequency-modulated current through space so that it may be picked up by the antenna at the receiving station T_2.

It is well known in the art that a radio circuit presents a transmission path of variable attenuation. That is to say, currents of different frequencies are differently attenuated at the same time of the day, etc. This transmission path might be replaced by a wired circuit or by any other well-known transmitting medium, and furthermore, the scope of this invention is not to be confined merely to transmitting media presenting varying attenuation properties.

At the receiving station T_2 the waves transmitted by the station T_1 are picked up by the antenna system and pass through tuning circuits TC, or other well-known receiving circuits, these tuning or other receiving circuits freely transmitting all currents within the limits of frequency variation of the transmitted carrier current. If the transmission path is one of unequal attenuation for different frequencies, as is the case here, the received current will not only vary in frequency in accordance with the frequency variations of the carrier current as transmitted from the transmitting station, but it will also vary in amplitude in accordance with the unequal attenuations presented to different frequencies by the transmitting medium. The amplitude variations of the carrier current are undesirable variations, and in signaling systems heretofore operated on the basis of frequency modulation, have caused distortion, fading, etc.

An amplifier A_2 receives the current transmitted by the tuning or receiving circuits TC and amplifies these currents preferably beyond a definite and predetermined level so that all of the amplified current has an energy level equal to, or greater than, the predetermined level. After amplification by the amplifier A_2 the current is transmitted through a limiting device L, which may be any power-limiting device well known in the art, such, for example, as is shown by H. J. van der Bijl, in the textbook, "The Thermionic Vacuum Tube," pages 373 and 374. This energy-limiting device definitely and continuously limits the amplitude of the current passing therethrough. Accordingly, the variations in amplitude introduced by the transmitting medium by virtue of its uneven attenuation characteristics, are effectively eliminated.

The current passing through the energy-limiting device L is then impressed on a translating circuit TR which translates frequency variations into corresponding amplitude variations. This is the property of an electrical wave filter when operated between a point almost identical with a cut-off point of the filter and some point outside the limits of free transmission of the filter, between which there is varying attenuation. That is to say, as currents having frequencies between the cut-off point of the filter and some point outside the normal range of the filter are impressed on the filter, there will be unequal attenuation of these currents, the attenuation increasing with departure of the frequency from the cut-off point of the filter. The attenuation characteristic which such a device might have is shown on the rectangle identified by the reference characters TR. A device having such an attenuation characteristic would attenuate current of a higher frequency by a greater amount than current of a lower frequency, and vice versa. Moreover, it is desirable when operating at high frequencies that the attenuation characteristic be even steeper than is provided by ordinary electrical wave filters. An electrical wave filter having a structure exhibiting properties of piezo electricity would have a much steeper attenuation characteristic. Accordingly, amplitude variations of the current transmitted by an electrical wave filter of the above mentioned type would be greater for a given frequency difference than those transmitted by a simple electrical wave filter, such as is described in the patent to G. A. Campbell, 1,227,113, dated May 22, 1917. It is to be understood, however, that the frequency-amplitude translating circuit TR is not to be confined merely to the circuit of an electrical wave filter, but that any other arrangement which effects a variation in amplitude with a variation in frequency might equally well be employed herein within the scope of the invention.

Current transmitted by the translating device TR then passes through a detector D which is preferably insensitive to frequency variations, wherein the signals are detected. After detection the signals are amplified by an amplifier A_3 of any well-known type, and, as amplified, are transmitted through an output circuit designated by the reference character S_2.

While it is preferable to have the modulation characteristic of the modulator at the transmitting station T_1 and the attenuation characteristic of the translating circuit TR at the receiving station T_2 both linear so that the amplitude of the signals transmitted by the translating circuit TR bears a definite relation to the amplitude of the signals impressed upon the modulator M, it is nevertheless to be understood that it is within the scope of this invention to employ any well known devices having non-linear modulation and attenuation characteristics, the modulation characteristic being concave upwardly when the attenuation characteristic is concave downwardly, and vice versa, resulting in any event in an overall linear characteristic.

Fig. 2 represents the current amplitude and current frequency variations as signals are transmitted through the system. The region between the reference characters *a* and *b* represents the amplitude variations in signaling currents. As the signaling currents pass through the modulator, current is transmitted which has frequency variations corresponding to the amplitude variations in the signaling currents. This is shown graphically by the region between the reference characters *b* and *c*. Thereafter the signals are amplified by the amplifier A_1 so that while there is substantially no amplitude variation of the current transmitted by the amplifier A_1, the frequency modulation, as effected by the modulator M, is preserved. Carrier current, modulated as to frequency, is then transmitted through space, wherein the modulated signaling current is un-

evenly attenuated, and it is then received by the tuning or receiving circuits TC with frequency variations corresponding to the original or modulating frequency variations and, moreover, with amplitude variations corresponding to the uneven attenuation properties of the transmitting medium. The region between the reference characters *e* and *f* shows graphically the nature of the wave transmitted by the tuning or receiving circuits TC. This current is then amplified by the amplifier A_2 to a level which brings all of the carrier current beyond a definite and predetermined level. The region between the reference characters *f* and *g* graphically shows the nature of the wave after amplification by the amplifier A_2. The amplified energy is then transmitted through an energy-limiting device L which chops off part of the signaling energy so as to render the undesirable amplitude variations, i. e., the variations introduced by the transmitting medium of un-uniform attenuation, substantially ineffective. The energy passing the energy-limiting device L is then impressed upon a frequency-amplitude translating circuit TR, which brings about variations in the amplitude of the output current corresponding to the frequency variations of the received current. The region between the reference characters *h* and *i* graphically represents the nature of the current passing the translating device TR. This current is detected by the detector D and then amplified by the amplifier A_3. The regions between the reference characters *i* and *j* and *j* and *k* correspond, respectively, to these latter processes.

Fig. 3 designates another form of embodiment of a receiving circuit which may be employed in this invention. In this circuit similar reference characters will be employed to designate parts similar to those of Fig. 1 of the drawing. The received current is passed through the tuning circuits TC, through the amplifier A_2 where the received current is amplified, and then through an energy-limiting device L which chops off part of the amplified energy in order to eliminate the undesirable effects of the amplitude variations of the carrier current. The squared tops on the carrier current which passes the energy-limiting device comprise a great many harmonics which may interfere with the faithful transmission and reproduction of the signaling currents. It is desirable to eliminate these harmonics and any other undesirable frequencies which tend to distort the signaling currents. Accordingly, the output of the energy-limiting device is impressed upon a filter of, for example, the Campbell type, referred to hereinabove. This filter transmits rather freely current within the frequency range employed in the frequency modulation of the carrier current, while substantially suppressing current of a frequency outside the normal limits of variation of the frequency of the carrier current. Inasmuch as the harmonics and other interfering frequencies lie outside of the band or range within which the carrier current varies in frequency, the filter F will substantially suppress these undesirable frequencies, and therefore render their effect upon the signaling currents nugatory. The output of the filter F is then transmitted through the translating circuit TR to bring about a conversion of the frequency variations into corresponding amplitude variations. The amplitude variations are then detected by the detector D, amplified by the amplifier A^3 and are then transmitted to the output circuit connected to the leads S_2. While the filter F and translating circuit TR have been designated as separate parts, it is to be understood that it is within the scope of this invention to combine these so that the combined apparatus will not only eliminate harmonics and other undesirable frequencies, but will also re-translate frequency modulations into corresponding amplitude variations, which may be conveniently detected and amplified thereafter.

While this invention has been shown in certain particular arrangements merely for the purpose of illustration, it is to be understood that the principles of this invention are capable of embodiment in other and widely varied forms, without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A radio telephone system comprising means for generating voice frequency currents, means for subjecting a carrier wave to frequency modulation by said currents, means for equalizing the amplitudes of said modulating wave, means for transmitting the same, means for receiving the said wave, means for re-equalizing the amplitudes thereof and means for translating the frequency modulation thereof into voice currents.

2. In a system for radio transmission of voice currents, the combination of means for generating a carrier wave, means for generating voice current, means for causing said current to modulate the carrier wave in frequency as well as in amplitude, means for equalizing the amplitudes of said wave a band filter for acting on said amplitude equalized wave and means for transmitting the said wave.

3. In a system employing modulations of frequency to convey signals, means for limiting the amplitude of the frequency modulated signals, and a filter connected to said means for eliminating harmonics produced by the said means.

4. In a system employing frequency modulations to convey signals, the combination of an energy-limiting device, a filter for eliminating extraneous currents produced by the limiting device, and means for converting the frequency modulations transmitted by the filter into amplitude variations, the filter immediately following the limiting device.

5. The method of signaling with modulations of frequency to convey signals, which consists in chopping off all energy exceeding a predetermined level, eliminating the effect of extraneous currents introduced by the chopping action and deriving the signals from the filtered energy.

6. In a frequency modulation system, a continuously acting amplitude limiter, a band filter for eliminating all frequencies beyond its limits, and a translating device for converting the frequency modulations into amplitude modulations, said filter being interposed directly between the limiter and the translating device.

7. In a receiver for frequency modulated currents, a tuned circuit upon which the received currents are impressed, a non-distorting amplifier coupled to the tuned circuit, means for continuously limiting the amplified energy, filtering means connected to the energy-limiting means, and means for converting the filtered energy into amplitude variations.

8. Means for eliminating undesired amplitude variations of frequency modulated current comprising an amplitude-limiting device, and a band filter directly connected to the limiting device to suppress frequencies transmitted thereto which exceed the limits of the filter.

9. In a system employing frequency modulations to convey signals, the combination of an energy-limiting device, a filter for eliminating extraneous currents produced by the limiting device and transmitting the frequency modulations conveying the signals, and means connected to said filter for converting the frequency modulations into amplitude variations.

10. In a frequency modulation system conveying signals, a continuously acting amplitude limiter, a band filter for eliminating all frequencies beyond its limits, and a translating device for converting the frequency modulations into amplitude modulations corresponding to the signals, said filter coupling said limiter and the translating device.

11. In a receiver for frequency modulated currents, a tuned circuit upon which the received currents are impressed, a non-distorting amplifier coupled to the tuned circuit, means for continuously limiting the amplified energy, means for converting the limited energy into amplitude modulated currents, filtering means connected to said converting means, and detecting means acting on the filtered, amplitude modulated currents.

12. The method of signaling with modulations of frequency to convey signals which consists in continuously chopping off all energy exceeding a predetermined level, eliminating the effect of extraneous currents introduced by the chopping action, and detecting and reproducing the original signals from the filtered energy.

13. In a system employing a band of frequencies representing frequency modulations to convey signals, the combination of an energy-limiting device, means coupled to said energy-limiting device for eliminating currents introduced by the energy-limiting device, and means coupled to the latter means for deriving and reproducing the original signals.

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