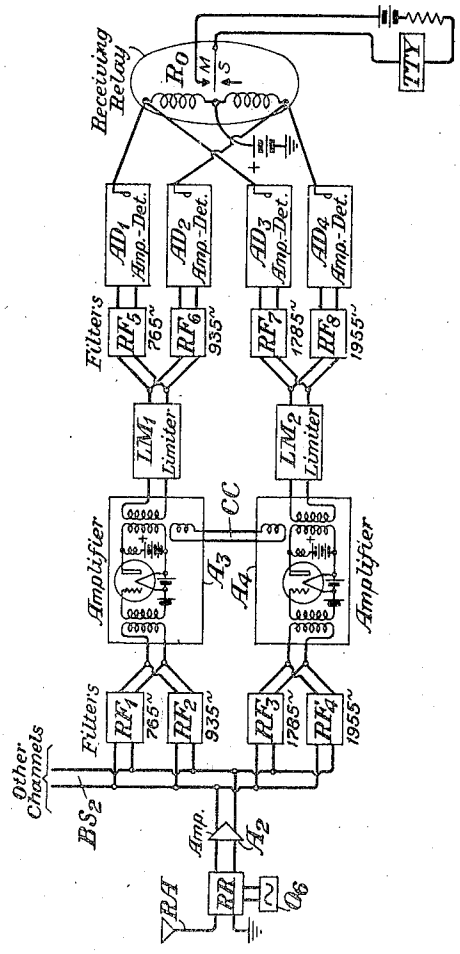
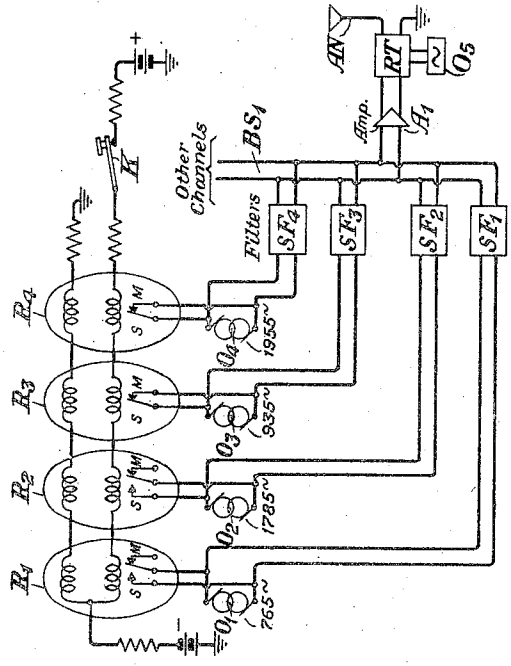
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FREQUENCY DIVERSITY TELEGRAPH SYSTEM

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## FREQUENCY DIVERSITY TELEGRAPH SYSTEM

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This invention relates generally to signaling systems, and more particularly to telegraph systems. Still more particularly, this invention relates to two-tone telegraph systems, as well as to frequency diversity telegraph systems employing either wire line, radio or other transmission media.

Telegraph signals are often transmitted either by interrupting the current of a battery or other source in accordance with the signals or by reversing the polarity of the current of the source, or by modulating an audio-tone by D. C. signals. In these types of transmission the transmitting medium may be such that the signals may be greatly attenuated and sometimes lost. It has been proposed to overcome the effect of the attenuation characteristic of the transmitting medium by employing a two-tone method for conveying the signals. In the two-tone method current of one frequency is produced for a marking signal and current of another frequency for a spacing signal. In order to reproduce the signals transmitted by the two-tone method, it has been proposed to employ a limiter at the receiver to substantially reduce the effect of the attenuation characteristic of the transmitting medium. However, when one of the currents, such as the marking current, becomes attenuated or faded, the limiter will introduce noise and extraneous currents and transmit these undesired currents to the telegraph receiving relay. Consequently the signals may be distorted and perhaps rendered unintelligible.

In accordance with this invention it is proposed to transmit telegraph signals over a transmitting medium having high attenuation by a frequency diversity two-tone method. By this method currents of two discrete frequencies will be produced for each single marking signal, and currents of two discrete but different frequencies will be produced for each spacing signal. At the receiving station of this system the currents of both the marking and spacing frequencies will be received and amplified. One limiter will be arranged to act on one of the marking frequencies and one of the spacing frequencies and another limiter will be arranged to act on the other marking frequency and the other spacing frequency. Each limiter will thus act on the currents of the two frequencies normally assigned to it in such a manner as to materially reduce the effect of noise and other extraneous currents. During periods of selective fading when only one of the two marking pulses, for example, may be reduced to or below the noise level at the receiver, the other pulse will be present at the receiver in sufficient magnitude for properly actuating the telegraph receiving relay.

Another feature of this invention is the provision of means for coupling the circuits of the two limiters to each other for further overcoming the effects of noise and other extraneous currents. The currents of the different frequencies received will be divided into two bands, namely, upper and lower bands, and each of the two bands of frequencies will be transmitted over a separate path. Each path will include a limiter, filtering apparatus and detecting apparatus. The equipment in each path will normally act on the currents of the band of frequencies assigned to it so as to reproduce the received signals. However, the two limiters will be electrically connected or coupled to each other in this invention, as already stated. If the lower band of frequencies, for example, becomes attenuated due to poor conditions of transmission, part of the higher band of frequencies will be diverted from its own path through the coupling circuit to the path for the lower band of frequencies. The limiter in the path of the lower frequencies will act on the higher band of frequencies received over the coupling circuit and greatly reduce the effect of noise or other extraneous currents in that path. After discriminating against noise and other extraneous currents, the filtering apparatus following the limiter in the lower band path will substantially suppress the currents of the higher frequencies which were acted on by the limiter of the lower frequency path. In other words, currents in the good path will be diverted to the limiter of the poor path to overcome noise during adverse conditions of transmission and the diverted currents will be thereafter suppressed.

This invention will be better understood from the more detailed description hereinafter following when read in connection with the accompanying drawing showing one embodiment of the invention merely for illustrative purposes.

Referring to the drawing, a sending station and a receiving station are illustrated, these stations being arranged for the multiplex transmission of a plurality of signals simultaneously. The apparatus required for the transmission of signals originating in one of the channels will alone be described, the remaining apparatus (not shown) being merely duplications of the equipment used for one signaling channel. When the key K is closed for the purpose of producing a marking pulse or signal, the lower windings of relays $R_1$, $R_2$, $R_3$ and $R_4$ will be energized so as to cause the

armatures of these relays to move to the right to close their marking contacts M. The opening of the spacing contacts S of relays $R_1$ and $R_2$ will remove the shunts around oscillators $O_1$ and $O_2$ so that the oscillators $O_1$ and $O_2$ may transmit currents of their individual frequencies to the sending filters $SF_1$ and $SF_2$, respectively. At the same time the closure of the marking contacts M of relays $R_3$ and $R_4$ will provide shunt circuits around the oscillators $O_3$ and $O_4$ and, therefore, substantially suppress any currents that may be generated by these oscillators. When the key K is opened for the purpose of producing a spacing signal or pulse, the armatures of the relays $R_1$—$R_4$ will move to the left to close their spacing contacts S, in which case the currents of oscillators $O_1$ and $O_2$ will be suppressed by the shunt circuits provided by the armatures of relays $R_1$ and $R_2$, respectively, while the shunts around oscillators $O_3$ and $O_4$ will be removed so that the individual currents of the latter oscillators will be transmitted to the sending filters $SF_3$ and $SF_4$, respectively.

Thus, currents of two frequencies corresponding to oscillators $O_1$ and $O_2$ will be transmitted in accordance with a marking signal, and currents of two different frequencies corresponding to oscillators $O_3$ and $O_4$—which are also different from the frequencies of oscillators $O_1$ and $O_2$—will be transmitted in accordance with a spacing signal. In order to better understand the invention, it may be stated that oscillators $O_1$ and $O_2$ may produce currents of, for example, 765 cycles per second and 1785 cycles per second, while the oscillators $O_3$ and $O_4$ may produce, for example, currents of 935 and 1955 cycles per second. These frequencies are mentioned only for illustration, and other frequencies widely different from those mentioned may be used within the scope of this invention. The sending bus $BS_1$ will, therefore, receive either the two marking frequencies of oscillators $O_1$ and $O_2$, or the two spacing pulses of oscillators $O_3$ and $O_4$, along with the marking and spacing currents of still other frequencies produced in other channels which are connected to the same bus $BS_1$. The currents reaching the bus $BS_1$ will be amplified by amplifier $A_1$, and then may be impressed upon a radio transmitter RT having an oscillator $O_5$ used for modulating the signaling frequencies to provide the much higher frequencies required for radio transmission via antenna AN.

Currents received by the receiving antenna RA at the receiving station are demodulated with current of an oscillator $O_6$ to reduce the received radio frequencies to their original positions in the frequency spectrum. Currents of the demodulated frequencies will be amplified by amplifier $A_2$ and impressed upon the receiving bus $BS_2$. The receiving filters $RF_1$ and $RF_3$ connected to the receiving bus $BS_2$ select and transmit only the currents of the marking frequencies generated at the transmitting station by oscillators $O_1$ and $O_2$, respectively. The receiving filters $RF_2$ and $RF_4$ connected to the receiving bus $BS_2$ select and transmit only the currents of the spacing frequencies generated at the transmitting station by oscillators $O_3$ and $O_4$, respectively. The outputs of the filters $RF_1$ and $RF_2$ are then combined and amplified by amplifier $A_3$, and are then transmitted through the limiter $LM_1$. The filters $RF_5$ and $RF_6$ connected to limiter $LM_1$ separate the marking and spacing frequencies from each other, and at the same time suppress harmonics and other effects produced by the limiter $LM_1$ itself. The currents transmitted by filters $RF_5$ and $RF_6$ are amplified and detected by the apparatus $AD_1$ and $AD_2$, respectively, and actuate the relay $R_0$ so as to move its armature to its marking contact M or spacing contact S.

Similarly the outputs of the filters $RF_3$ and $RF_4$ are combined in a common amplifier $A_4$ and are then transmitted through a separate limiter $LM_2$. The output of limiter $LM_2$ is connected to filters $RF_7$ and $RF_8$, which separate the other marking and spacing frequencies from each other and at the same time eliminate harmonics and other extraneous currents introduced by the limiter $LM_2$. The filters $RF_7$ and $RF_8$ are connected to the amplifier-detectors $AD_3$ and $AD_4$, respectively, which transmit the marking and spacing currents to the telegraph receiving relay $R_0$, causing the armature of this relay to move to its marking contact M or its spacing contact S in accordance with the received signals. The armature of the relay $R_0$ may be employed to control the operation of a teletypewriter TTY, or a recorder of any well-known type, or any other signal indicating apparatus.

Whenever one of the frequencies, such as one of the marking frequencies of, for example, 765 cycles, becomes substantially reduced in amplitude due to fading or other properties of the transmission medium, current of the other marking frequency of 1785 cycles conveying the same marking signals will be present in the limiter $LM_2$. Consequently the marking signal will be transmitted to the receiving apparatus including the receiving relay $R_0$. The limiters $LM_1$ and $LM_2$ will, therefore, effectively select the stronger of the two currents of the marking frequencies and transmit the currents of that frequency to the practical exclusion of noise and other extraneous currents. Likewise the limiters $LM_1$ and $LM_2$ will effectively transmit the stronger of the two currents of spacing frequencies and eliminate noise and other effects. In general, therefore, the receiving relay $R_0$ will be operated to respond to the marking and spacing signals, and the effect of noise and attenuation changes in the system will be considerably reduced. This is one of the features of this invention.

At times one of the marking currents of, for example, 765 cycles, may be absent from one of the paths of the receiving circuit due to adverse conditions of the transmitting medium. During any such occasions the amplifier $A_3$ will receive from amplifier $A_4$ of the other path some of the marking current of 1785 cycles. The 1785 cycle marking current will be received by amplifier $A_3$ over the coupling circuit CC which has a low, but predetermined loss. The 1785 cycle marking current will then be limited by limiter $LM_1$ so as to substantially reduce the effect of noise and extraneous currents. The 1785 cycle marking current will thereafter be suppressed by filters $RF_5$ and $RF_6$ which cannot transmit the higher frequency marking current of 1785 cycles. Consequently no current will then be detected by the marking detector $AD_1$ (or by the spacing detector $AD_2$). The receiving relay $R_0$ will therefore respond to the marking current of 1785 cycles as it is detected normally by detector $AD_3$. This arrangement will thus prevent the false operation of relay $R_0$ when the 765 cycle marking current is faded considerably.

If both the marking frequency of 765 cycles and the spacing frequency of 935 cycles are faded, then the coupling circuit CC will divert to amplifier $A_3$ some of the higher frequency marking

current, of 1785 cycles and some of the higher frequency spacing current of 1955 cycles. These currents will then be alternately acted on by limiter $LM_1$ to overcome noise and other undesired currents. These higher frequency currents will thereafter be suppressed by filters $RF_5$ and $RF_6$. If the higher frequency currents are attenuated by the transmitting medium, the coupling circuit CC will likewise divert some of the corresponding lower frequency currents from the amplifier $A_3$ to the amplifier $A_4$ for the same purpose, as will be readily apparent.

Without the coupling or connection of the two channels or paths by the coupling circuit CC as shown and just described, the absence of the current of one of the spacing frequencies of, for example, 1955 cycles will cause the limiter $LM_2$ to transmit noise currents to the spacing filter $RF_8$, which in turn will be conveyed to the receiving relay $R_0$ to cause it to operate falsely. The coupling of the two channels or paths greatly improves the operation of the system and aids in the elimination of erroneous signals.

Although the amplifiers $A_3$ and $A_4$ are shown coupled to each other for the purpose of eliminating noise and other such effects, it will be understood that the limiters $LM_1$ and $LM_2$ may be so coupled, if desired, to produce the same result. To accomplish this same end by coupling the limiters $LM_1$ and $LM_2$, it will be necessary simply to connect or couple the input circuits of the limiters to each other by a coupling circuit such as CC or in any well-known manner.

By producing two or more currents of different frequencies for the transmission of a signal, such as a marking signal, and two or more similar currents of different frequencies for the transmission of a spacing signal, and having a limiter act on these currents as already described, a substantial improvement in transmission has been observed. A further distinct improvement has been observed by coupling of the two channels to each other at the receiver, as already described.

Although a key K is shown for producing the marking and spacing signals at the transmitter merely for illustrative purposes, it will be understood that the signals transmitted may be produced by a teletypwriter or by any other means.

Although the frequency diversity system of this invention has been shown and described in connection with a radio system, the invention is equally applicable to systems transmitting signals over land lines or other media. Although the invention has been shown in regard to the transmission of signals from one point to another, it is equally applicable to two-way transmission.

While this invention has been shown and described in certain particular embodiments merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a frequency diversity signaling system in which signals are transmitted by means of currents positioned in a first frequency range and the same signals are simultaneously transmitted by means of currents positioned in a second frequency range, the combination of two current limiters which separately receive the currents within said first and second frequency ranges, means for coupling said limiters to each other so that the currents limited by one of the limiters may also be limited by the other limiter, filtering apparatus connected to one of the limiters for transmitting only the currents lying within said first frequency range, and separate filtering apparatus connected to the other of the limiters for transmitting only the currents lying within said second frequency range.

2. In a frequency diversity signaling system in which signals are transmitted by means of currents positioned in one frequency range and the same signals are simultaneously transmitted by means of currents positioned in a different frequency range, the combination of two amplifiers for separately amplifying the currents of the two different frequency ranges, two limiters connected respectively to said amplifiers for limiting the amplitudes of the currents amplified by said amplifiers, means for coupling the output circuits of said amplifiers to each other so that the amplified currents limited by one of the limiters may also be limited by the other limiter, filtering apparatus connected to one of the limiters for transmitting only the currents amplified by the amplifier to which said limiter is connected, and separate filtering apparatus connected to the other of the limiters for transmitting only the currents amplified by the amplifier to which the latter limiter is connected.

3. In a telegraph system in which a marking signal is transmitted by means of a plurality of currents at different frequencies and a spacing signal is transmitted by means of a plurality of currents of different frequencies, the combination of two amplifiers, one of which amplifies certain of said currents, the other amplifier amplifying the remaining currents, two limiters, two filters, one limiter and one filter being connected in tandem to each of said amplifiers, means for coupling the two amplifiers to each other so that the currents amplified by both amplifiers will be applied to each limiter, and detecting apparatus connected to both filters to reproduce the marking and spacing signals.

4. In a frequency diversity telegraph system in which each marking signal and each spacing signal is transmitted by means of a plurality of currents of different frequencies, the combination of two amplifiers, two limiters connected to said amplifiers, respectively, one of the amplifiers and its associated limiter acting on certain of the currents corresponding to each marking signal and each spacing signal while the other amplifier and limiter acts on the remaining currents corresponding to each marking signal and each spacing signal, filtering means connected to said limiters, common detecting apparatus connected to said filtering means for reproducing the signals, said amplifiers being directly coupled to each other so that all of the currents corresponding to the marking and spacing signals may be applied to each limiter.

5. In a telegraph system in which two alternating currents of different frequencies are employed to transmit a marking signal and two alternating currents of different frequencies are employed to transmit a spacing signal, the combination of a first limiter for limiting one of the currents corresponding to each marking signal and one of the currents corresponding to each spacing signal, a second limiter for limiting the remaining currents corresponding to each marking signal and each spacing signal, first and second filters connected, respectively, to said limiters for selectively transmitting the currents acted on by said limiters, common detecting ap-

paratus connected to said filters for reproducing the marking and spacing signals, and means for coupling said first and second limiters to each other so that the first limiter may act on the currents transmitted to the second limiter and the second limiter may act on the currents transmitted to the first limiter.

6. In a telegraph system in which each marking signal is transmitted by means of currents of two different frequencies and each spacing signal is transmitted by means of currents of two other frequencies, the combination of receiving apparatus for receiving said signals, said receiving apparatus including a detector for reproducing said marking and spacing signals, said detector being supplied with the currents to be detected over two different paths, each path including a limiter, a band pass filter connected to the output of the limiter, and means for coupling the limiters of the two paths to each other.

7. In a telegraph system, the combination of first and second limiters, said limiters receiving alternating currents corresponding to a marking signal and other alternating currents of different frequencies corresponding to a spacing signal, first and second filters connected, respectively, to said limiters, the first filter transmitting only the lower frequency currents corresponding to the marking and spacing signals, the second filter transmitting only the higher frequency currents corresponding to the same marking and spacing signals, detecting apparatus connected to both of said filters, and means for coupling said limiters to each other so that both limiters may act on the same alternating currents.

8. In a telegraph system in which two currents of different frequencies are employed to transmit a marking signal and two currents of different frequencies are employed to transmit a spacing signal, the combination of first and second limiters for receiving, respectively, two portions of the currents corresponding to the marking and spacing signals in two different frequency ranges, first and second filters connected respectively to the outputs of said limiters, the first filter transmitting only the currents in one of said frequency ranges, the second filter transmitting only the currents in the other frequency range, detecting means connected to both filters for reproducing said marking and spacing signals, and means for coupling said limiters to each other so that each limiter may limit the currents transmitted through the other limiter.

9. In a telegraph system in which a current of low frequency and a current of high frequency are employed to transmit each marking signal and another current of a different low frequency and another current of a different high frequency are employed to transmit each spacing signal, the combination of first and second limiters for separately limiting the amplitudes of the low frequency currents and the high frequency currents, low and high pass filtering apparatus connected respectively to said first and second limiters for separately filtering the low frequency currents and the high frequency currents, means comprising a predetermined low loss path for coupling said limiters to each other so that both limiters may limit the amplitudes of the currents of the same frequencies, and means coupled to said filtering apparatus for reproducing said marking and spacing signals.

10. In a signaling system for telegraph signals in which each marking signal and each spacing signal is conveyed by a plurality of alternating currents, the combination of two filters for separating said currents into two bands occupying different ranges in the frequency spectrum, two amplifier-limiters connected respectively to said two filters, means for coupling said amplifier-limiters to each other, two additional filters of the same frequency characteristics as said first filters and connected respectively to said amplifier limiters for receiving the limited currents, and means coupled to said amplifier-limiters to reproduce said signals.

11. In a signaling system in which a plurality of currents of different frequencies are employed to transmit each of the signals, the combination of two paths including means for receiving the low frequency currents and the high frequency currents respectively, each path including a limiter by a filter, the filter of each path passing only the currents having the frequencies received by that path, a low loss circuit coupling the limiters of the two paths, and means connected to said filters for reproducing the signals.

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