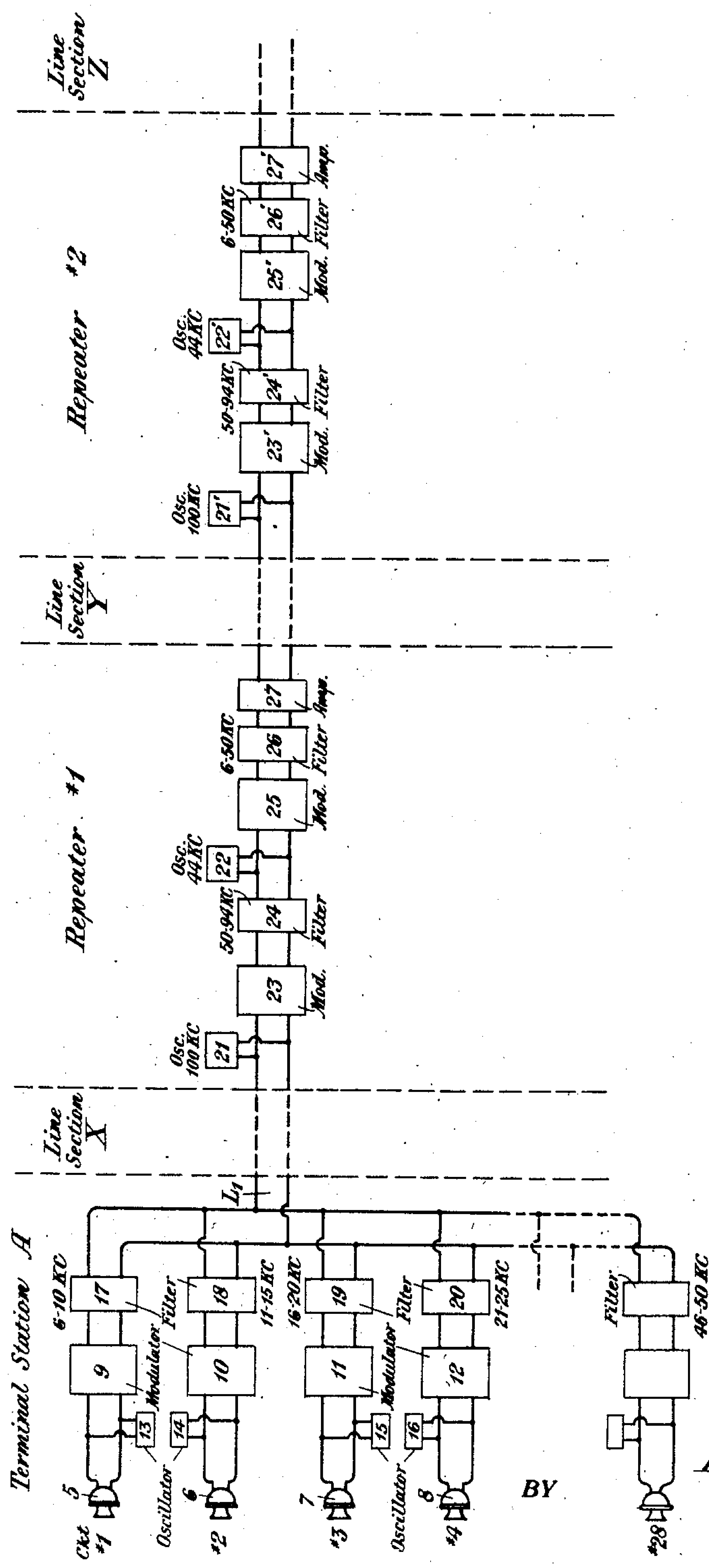
Aug. 20, 1929. E. I. GREEN 1,724,925

CARRIER SIGNALING SYSTEM

Original Filed Dec. 30, 1925



INVENTOR
E.I. Green
BY
ATTORNEY

Patented Aug. 20, 1929. 1,724,925

UNITED STATES PATENT OFFICE.

ESTILL I. GREEN, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

CARRIER-SIGNALING SYSTEM.

Application filed December 30, 1925, Serial No. 78,454. Renewed November 11, 1926.

This invention relates to carrier signaling systems, and particularly to a method and means for substantially equalizing the transmission equivalents of a plurality of channels differing in frequency transmitted over or through the same transmitting medium.

In carrier systems having several repeaters, it has been found necessary to equalize the volumes of the various channels before amplifying them at each repeater in order to keep the highest frequency channel (which has the greatest attenuation) above the noise level and at the same time to keep the lowest frequency channel (which has the least attenuation) below the overload point of the repeaters. This equalization of the various channels is ordinarily carried out by means of networks which reduce all channels to the same level at each repeater point. This practice of reducing the volumes of all the channels to substantially the same level, which in practice is the level of the highest frequency channel, is highly inefficient because of the waste of energy of the lower frequency channels.

This invention resides in a method and means for equalizing the transmisson equivalents of a plurality of channels of different frequencies transmitted over or through a common transmitting medium, which method consists in inverting the channel frequencies in alternate repeater sections. Such method has distinct advantages over the method heretofore employed in that the present method equalizes the channels with respect to their frequency of transmission, which is the real difference between the channels, rather than with respect to attenuation, which is only a characteristic of the frequency. The equalization of the channels with respect to frequency effectively provides equalization with respect to all the factors which are a function of frequency, such as gain, noise, cross-talk, attenuation variations, and other similar functions.

This invention will be clearly understood from the following description when read in connection with the attached drawing, showing symbolically a form of embodiment of the invention.

In the drawing, the terminal station A comprises a plurality of branch circuits each intended for the handling of one of the channels of transmission. Thus circuit 1 is intended to handle one of the channels of transmission, which channel represents preferably one of the side bands produced by the modulation of a carrier frequency by a signal frequency, as, for example, the band of speech frequencies, and, in like manner, circuits 2, 3 and 4 are each adapted to handle other channels of transmission. All of the branch circuits, which, taken together make up the terminal station, are connected with a common transmitting medium, such as the wire circuit L_1. The transmission line L_1 is made up of a plurality of line sections, some of which, designated X, Y and Z, are shown. These sections are connected by means of repeaters. Thus, repeater No. 1 is connected between sections X and Y, and repeater No. 2 between Y and Z. The section Z may be connected with another repeater interposed between it and a succeeding section of the line L_1, or it may be connected with a terminal station substantially similar to station A. In any event, the distant end of the line L_1 would be terminated by a plurality of branch circuits, such as is shown in station A.

At station A the transmitters 5 to 8, inclusive, represent symbolically any means for impressing a modulating current upon the input sides of a plurality of modulating devices 9 to 12, inclusive, which, respectively, are connected with the circuits 1 to 4, inclusive. While these modulating devices may be of any well-known type, a preferable form is a vacuum tube arrangement characterized by the suppression of the carrier frequency, which is disclosed in the patent to Carson, No. 1,449,382, dated March 27, 1923. Also connected with the input sides of the modulators 9 to 12, inclusive, are the sources of carrier frequency 13 to 16, respectively, each of which is adapted to produce a frequency that differs from the others. A plurality of filters, designated 17 to 20, inclusive, are connected with the output circuits of the modulators 9 to 12, respectively. The filters 17 to 20, inclusive, are in turn connected with the line L_1. While the circuits 1 to 4 represent only the transmitting branches for the channels of transmission, it is to be understood, of course, that receiving branches of well-known types would ordinarily be employed at the terminal station A to receive at that terminal station the currents of each channel which are transmitted from the distant end by circuits such as are shown in the drawing.

Repeater No. 1 comprises two oscillators 21 and 22, the former being connected across the line L_1 at the input side of the modulator 23. A filter 24 is connected across the output side of the modulator 23. The oscillator 22 is connected across the input side of the modulator 25, across the output side of which is a filter 26 which is also connected with the input side of an amplifier 27. The output side of this amplifier is connected with the line section Y, which in turn is connected with the repeater No. 2, having parts similar to those shown at repeater No. 1 and which bear the same designating numerals primed. The manner in which this circuit operates in order to attain the objects of the invention is as follows:

Let it be assumed that the oscillator 13 of the branch circuit 1 is producing such a carrier frequency that when modulated by the signal frequency produced by 5, it will produce such side bands that one of them, namely, the one transmitted by the filter 17, will have the range of 6 to 10 kilocycles. In like manner, the circuit 2 will have a source of oscillations of such frequency that the selected side band will have the range of 11 to 15 kilocycles, channel 3 a selected range of 16 to 20 kilocycles, channel 4, 21 to 25 kilocycles, and other channels which may be connected with the line L_1 may have other frequencies ranging up to 50 kilocycles. All of the frequencies represented by the various channels would, when impressed upon the line L_1, be transmitted thereover. At repeater No. 1 the frequencies present in the channels would be operated upon by the apparatus present at the repeater in such manner that the frequencies of the channels would be inverted, amplified and transmitted over the line section Y to repeater No. 2, where the frequencies impressed on that repeater would again be inverted and amplified and transmitted over section Z. By this inversion of the frequencies, the channels of higher frequencies which were attenuated most in the transmission over line section X would be translated to lower frequencies so as to be least attenuated in transmission over section Y, and similarly the channel of lower frequencies that had the least attenuation in transmission over section X would be translated to higher frequencies by repeater No. 1, which would have the greater attenuation in transmission over section Y. In this manner the equivalents of the various channels are maintained substantially equal. The manner in which each of the repeaters operate to produce this result will be clear by describing what happens at repeater No. 1. The assumed range of frequencies extending from 6 to 50 kilocycles will be beaten in the modulator 23 with a source of oscillations 21, producing a frequency f_3, which is equal to or greater than twice the maximum frequency found in the channels transmitted over the line L_1. This maximum frequency in the present assumed case is 50 kilocycles, so that the frequency of the oscillator 21 should be 100 kilocycles. The filter 24 is designed to transmit only the difference frequencies of modulation, that is to say, the frequencies represented by the difference between 100 kilocycles and the frequencies of the channels, which, in the present instance, ar assumed to have the range of from 6 to 50 kilocycles. Thus channel 1, which at terminal station A has a range of 6 to 10 kilocycles, becomes, after passing through the filter 24, 90 to 94 kilocycles, and the channel at station A, which has the highest frequency, namely 46 to 50 kilocycles, passes through the filter 24 as 50 to 54 kilocycles. In other words, the range at terminal station A of 6 to 50 kilocycles becomes at the filter 24, 50 to 94 kilocycles. These frequencies, which are transmitted by the said filter, are then beaten with oscillations from the source 22 which has a frequency f_4 which is equal to $f_3-(f_1+f_2)$, where f_3 is the frequency of the oscillator 21, f_1 the lowest frequency present in all of the channels on the line L_1, and f_2 the highest frequency present. In the present case, $f_1+f_2=56$, so that the frequency f_4 of the oscillator 22 must be 44 kilocycles. Thus the frequencies transmitted through the filter 24, which range from 50 to 94 kilocycles, will be beaten with 44 kilocycles and produce difference frequencies ranging from 6 to 50 kilocycles, which difference frequencies will be transmitted by the filter 26 and amplified by 27. It has been pointed out that the frequency 94 transmitted through the filter 24 corresponds to the frequency 6 of channel 1 at station A, and the frequency 50 corresponds to the frequency 50 of channel 28 at station A. The frequencies transmitted through 24, when beaten with the oscillations of 44 kilocycles, produce sum and difference frequencies, the difference frequencies ranging from 6 to 50 kilocycles. The frequencies in the line section X will be thus completely inverted because the frequency of 50 kilocycles at the filter 26 corresponds to 6 kilocycles at terminal A, and 6 kilocycles at the filter 26 corresponds to 50 kilocycles at station A. It will accordingly be seen that the higher frequencies at station A, which were transmitted over section X of the line and attenuated to the highest degree, have been so reduced in frequency by the beating operations at repeater No. 1 that they will not be subjected to such a high degree of attenuation after being amplified by the amplifier 27 and transmitted over section Y of the line L_1 to the repeater No. 2. The lower frequencies transmitted over section X of the line, which were least attenuated, are translated at repeater No. 1 to higher frequencies which, when amplified by 27 and transmitted over the line section Y, will be subjected to greater attenuation than the lower frequencies transmitted thereover. At repeater No. 2 the higher frequencies are converted to lower frequencies, and the lower frequencies to higher frequencies, so that as the result of such frequency translation at the repeaters connected with the line L_1, the equivalents of a plurality of channels are maintained substantially equal. These frequencies comprising the various channels will be received at a terminal station connected with the distant end of the line L_1 and translated, so that the signals impressed upon the transmitters 5 to 8, inclusive, at terminal A will be detected. While the arrangement shown in the drawing represents only a one-way system, it is to be understood, of course, that the system may be rendered operative in both directions by methods well known to those skilled in the art.

By means of the system of double beating disclosed herein, it is possible to effect the inversion of a plurality of frequencies present in a plurality of channels of transmission without dividing the channels into groups and translating each of these groups separately, which method is disclosed in the copending application of Green, Serial No. 78,455, filed December 30, 1925, Patent No. 1,677,966, granted July 24, 1928.

While this invention has been disclosed as embodied in a particular form, it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. The method of equalizing the transmission equivalents of a plurality of carrier channels which consists in transmitting the currents representing a plurality of channels of different frequencies, beating all of the frequencies with a beating frequency which is at least twice as great as the highest frequency, selecting the difference frequencies resulting from said beating operation, beating the said difference frequencies with a beating frequency equal to the difference between the said first beating frequency and the sum of the lowest and the highest frequency in all of the said channels, selecting the difference frequencies from the said second beating operation, and transmitting the selected frequencies.

2. The method of equalizing the transmission equivalents of a plurality of carrier channels which consists in beating a plurality of frequencies with oscillations whose frequency is at least twice as great as the highest frequency in all of the said channels, and selecting the difference frequencies in each channel, beating the selected frequencies with a frequency equal to the difference between the first beating frequency and the sum of the lowest and the highest frequencies in all channels, selecting the difference frequencies of the latter beating operation, amplifying and transmitting the latter selected frequencies.

3. In a carrier signaling system, the combination with a transmission line of a repeater between sections thereof, a source of current representing a plurality of channels of transmission connected with the said line, the said repeater comprising a source of beating oscillations whose frequency is at least twice that of the maximum frequency of all channels, a filter to pass the difference frequencies from the said beating operation, a second source of beating oscillations whose frequency equals the difference between the frequency of the said first source and the sum of the lowest and highest frequencies in all channels, and a filter to select the difference frequencies from the said second beating operation.

4. In a carrier signaling system, the combination with a transmission line of a repeater between sections thereof, a source of current representing a plurality of channels of transmission connected with the said line, the said repeater comprising a source of beating oscillations whose frequency is at least twice that of the maximum frequency of all channels, a filter to pass the difference frequencies from the said beating operation, a second source of beating oscillations whose frequency equals the difference between the frequency of the said first source and the sum of the lowest and highest frequencies in all channels, a filter to select the difference frequencies from the said second beating operation, and an amplifier to amplify the selected frequencies.

5. The method of equalizing the transmission equivalents of a plurality of carrier channels, which consists in transmitting the currents representing a plurality of channels of different frequencies, beating all of the said frequencies with a beating frequency of predetermined magnitude, selecting one of the bands of frequencies resulting from the said beating of each channel, beating the selected bands with another beating frequency and selecting that band of each channel that contains the frequencies that are an inversion of the frequencies of the same channel prior to the first beating operation.

6. In a multi-channel high frequency signaling system, the method of equalizing the over-all line attenuation for several simi-

larly directed channels, which consists in beating the frequencies of each channel with the same beating frequency, selecting one of the bands of each channel resulting from such beating and beating it with another beating frequency, and selecting one of the bands of each channel resulting from the second beating operation, the said beating frequencies being so chosen that the frequencies of the first selected band of each channel when beaten with the second beating frequency shall produce a band of that channel which is the inverse of the frequencies of that same channel prior to the first beating operation.

In testimony whereof, I have signed my name to this specification this 29th day of December, 1925.

ESTILL I. GREEN.