Nov. 23, 1926. **1,607,683**

DE LOSS K. MARTIN

RADIO REPEATER SYSTEM

Filed March 22, 1924

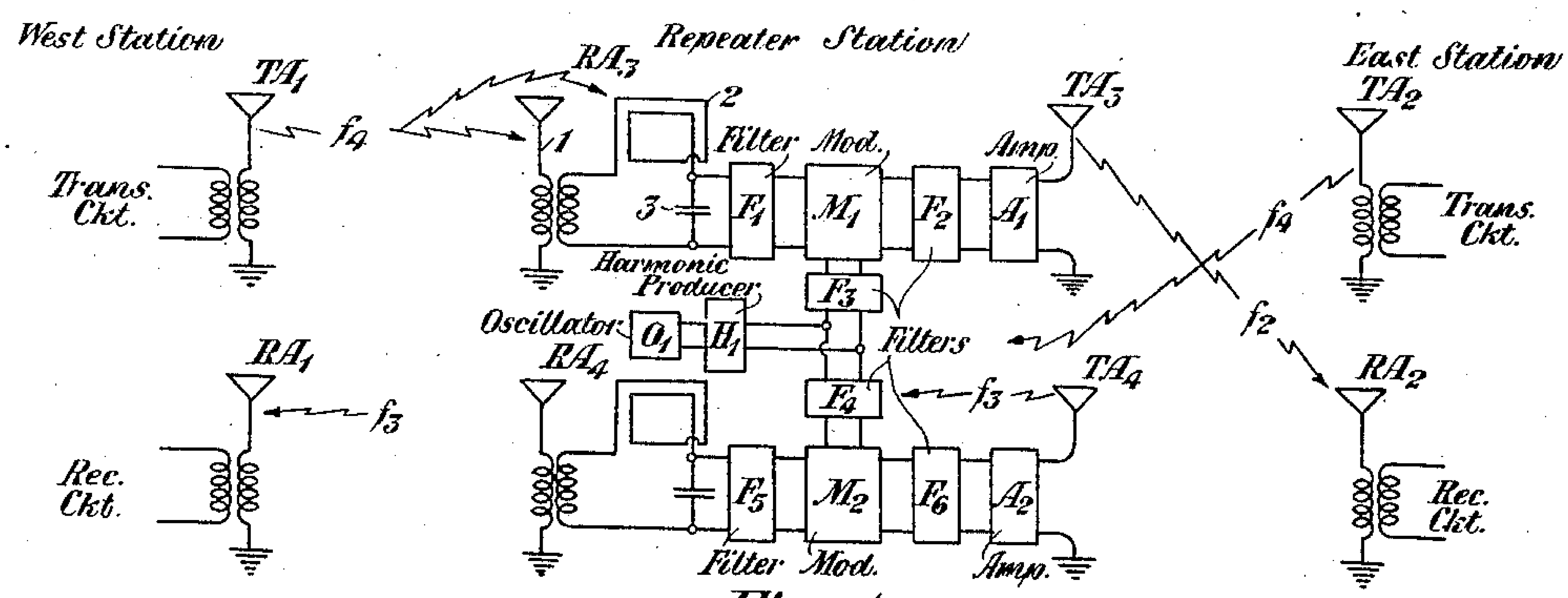

Fig. 1

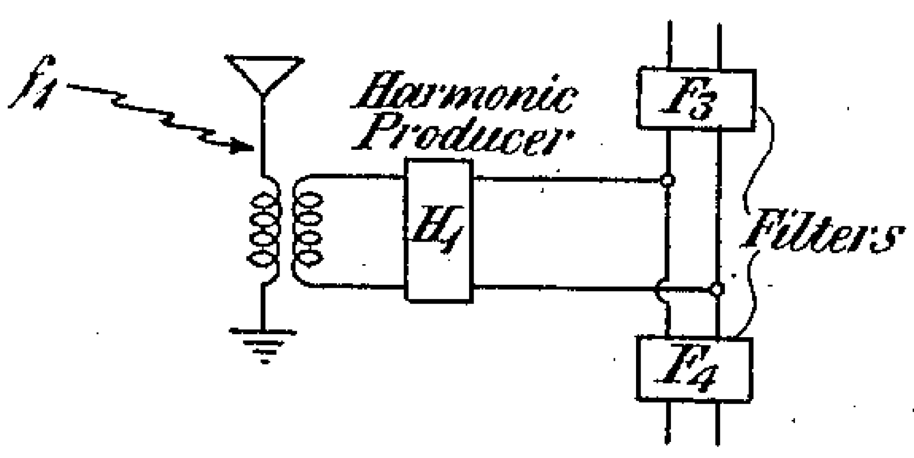

Fig. 1a

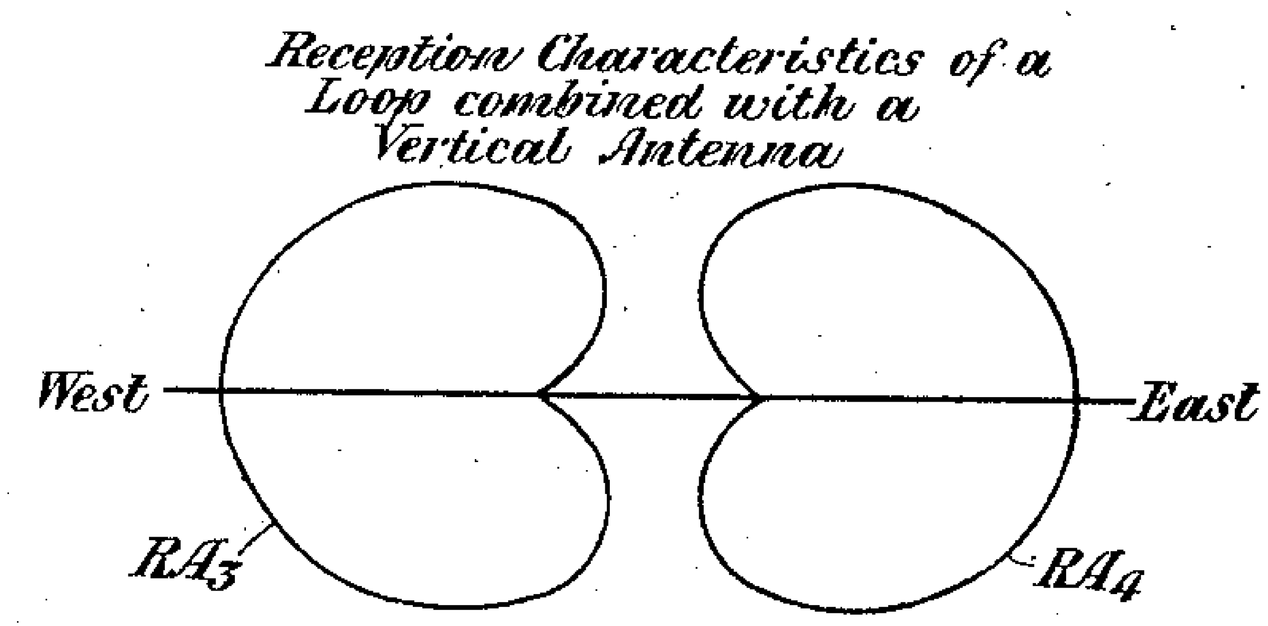

Fig. 2

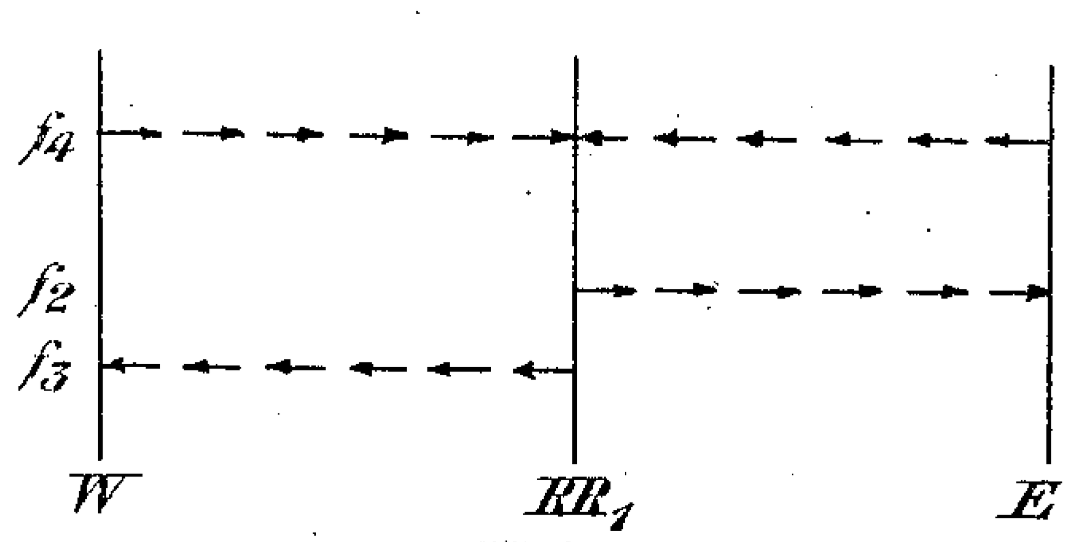

Fig. 3

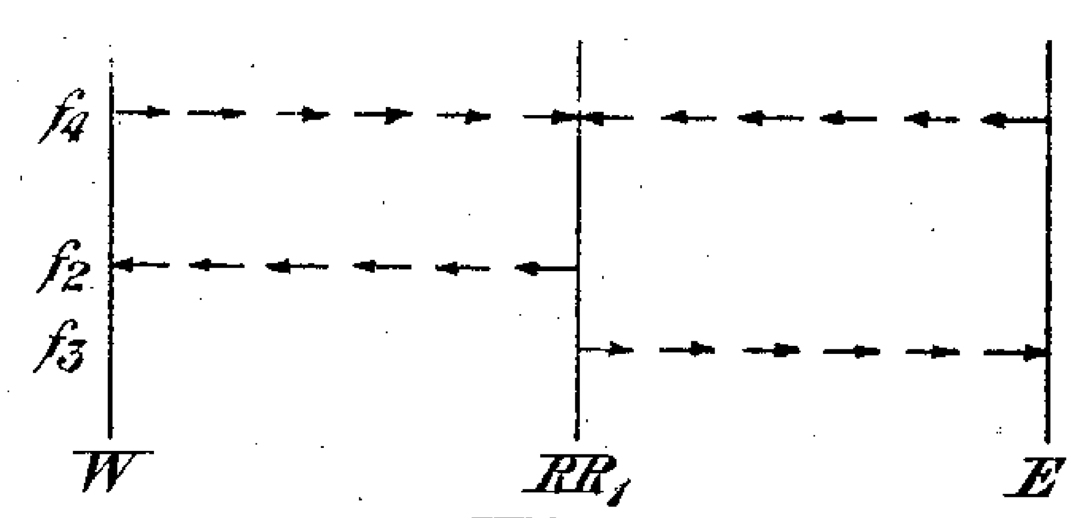

Fig. 3a

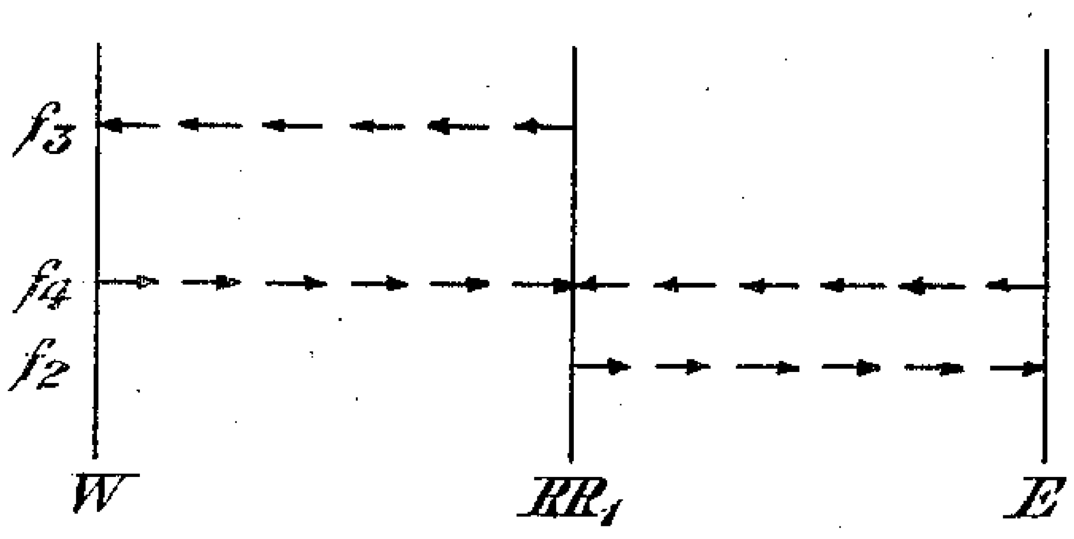

Fig. 4

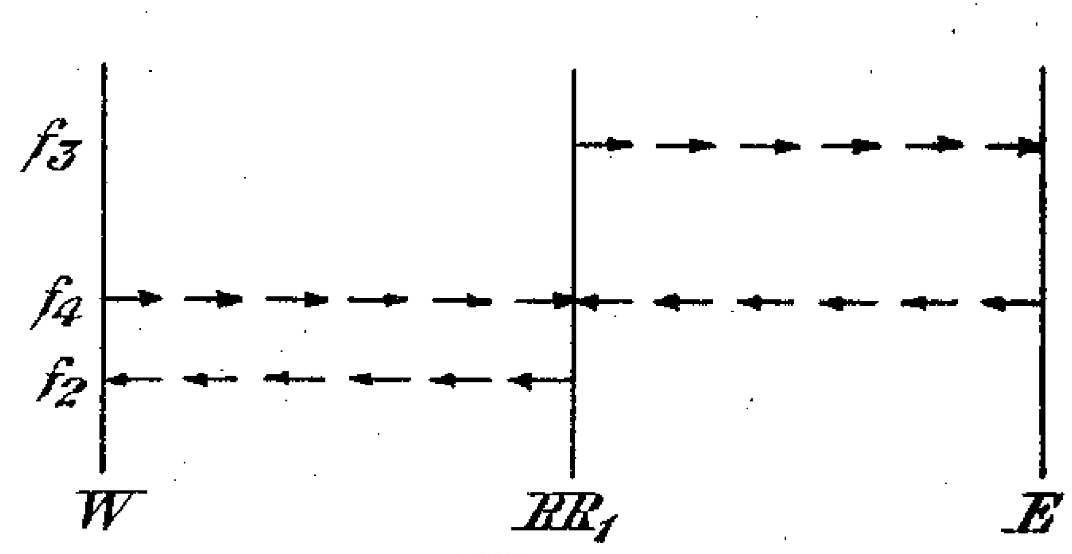

Fig. 4a

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UNITED STATES PATENT OFFICE.

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RADIO REPEATER SYSTEM.

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This invention relates to radio signaling systems, and particularly to a method and means for operating a system employing a single repeater station between the terminal stations thereof, which method is characterized by the changing of the frequencies of the received waves at the repeater station in accordance with a definite plan, whereby singing of the repeater or between the repeater and a terminal station may be prevented and whereby the number of frequencies per channel does not exceed three.

In the operation of a long distance radio system having one or more repeaters between the terminal stations thereof, it has heretofore been necessary to change each received frequency of each transmission channel at each repeater to a different frequency in order to prevent currents transmitted from the same repeater from entering the receiving circuits thereof or the receiving circuits of other channels at a distant repeater or terminal station. For a system without repeaters, two frequencies are normally required for each two-way channel, one for transmitting in one direction and another for transmitting in the opposite direction. Considering, for the purpose of illustration, a system of the prior art having two terminal stations and a single repeater therebetween, if we transmit from one terminal a frequency f_1 and from the other a frequency f_2, singing may be prevented only by changing at the repeater the frequency f_1 to a third frequency such as f_3 before radiating it therefrom to the distant terminal to which it is intended to go; and similarly, by changing the frequency f_2 to a fourth frequency such as f_4 before radiating it therefrom. While singing will thereby be avoided both at the repeater station and also with the terminal stations, it is obvious that this result is obtained only by a liberal use of the frequency spectrum since the system requires four frequencies to effect two-way transmission between terminal stations of a system involving only one repeater.

It is the object of the present invention to provide a method and means for effecting two-way communication between two radio stations of a system employing a repeater therebetween, the said method being characterized by the selective reception at the repeater station of waves transmitted from each terminal station at the same frequency, translating the received waves into waves whose frequencies differ from each other, and transmitting the waves as thus translated.

This invention will be clearly understood from the following description when read in connection with the attached drawing of which Figure 1 shows in schematic form an embodiment of the invention; Fig. 1^a shows a modification of a detail of Fig. 1; Fig. 2 shows the reception characteristic of an antenna structure of the form shown in Fig. 1, comprising a loop and a vertical antenna; and Figs. 3, 3^a, 4 and 4^a show the frequency distribution of a system of communication in which this invention is embodied.

In Fig. 1 there are represented two terminal stations, designated, respectively, the west station and the east station, and a repeater station intervening therebetween, the function of which is to receive waves transmitted from the terminal stations, to translate and amplify the same and to transmit to the respective terminal stations the waves as thus acted upon. At the west station there is represented a transmitting antenna TA_1 and a receiving antenna RA_1, each of which has connected therewith a circuit for transmitting and receiving, respectively. Similarly, at the east station there are provided the transmitting antenna TA_2 and the receiving antenna RA_2 with suitably associated circuits, which may be of any well-known type. The repeater station comprises the receiving antenna structures RA_3 and RA_4, the former of which is made up of the vertical antenna 1 and the loop antenna 2 with the condenser 3 for tuning the same. The antenna structure RA_4 comprises similar elements. Connected with the antenna structure RA_3 is the band filter F_1, a modulator M_1, a second band filter F_2 and an amplifier A_1, the output side of which is connected with the transmitting antenna TA_3. Similarly, the antenna structure RA_4 has connected therewith the filter F_5, the modulator M_2, the filter F_6 and the amplifier A_2, the output side of which is connected with the transmitting antenna TA_4. O_1 is a source of high frequency oscillations connected with a harmonic producer H_1, which, as its title signifies, is adapted to produce a plurality of harmonics of the fundamental frequency created by O_1. F_3 and F_4 are filters each adapted to pass a certain harmonic produced by H_1.

The receiving antennæ RA_3 and RA_4 are designed and adjusted in ways well-known to those skilled in the art for receiving signals efficiently from only one direction. It is well-known that an antenna structure comprising a vertical antenna, such as 1 of RA_3, and a loop, such as 2, may have directional characteristics, such as shown in Fig. 2, viz, by the proper adjustment of the constants of each antenna circuit and by proper orientation of the loop, the combined structure may be caused to receive most efficiently from one direction only, as shown by the characteristics constituting Fig. 2. For example, the antenna structure RA_3 may be adjusted to receive efficiently from the west, viz, signals transmitted from the antenna TA_1, and the antenna structure RA_4 may in like manner be adjusted to receive efficiently from the east, that is, the frequency transmitted from the antenna structure TA_2 of the east terminal station.

The manner in which the aforedescribed system operates is as follows:

Let it be assumed that the transmitting frequency from both terminal stations is f_4, as shown in Fig. 3. Oscillations of this frequency from both directions will fall upon the antennæ RA_3 and RA_4 of the repeater station RR_1 located therebetween. Assuming that the antenna RA_3 has the reception charactertistic represented by the left-hand diagram of Fig. 2, it will receive efficiently the waves of the frequency F_4 transmitted from the antenna TA_1 of the west station and will be substantially unaffected by waves of the same frequency transmitted from the antenna TA_2 of the east station. The oscillations of the frequency f_4, which, for the purpose of illustration may be assumed to be of 750 kilocycles, will be passed by the filter F_1 and be impressed upon the modulator M_1. Let it be assumed also that the oscillator O_1 is generating a wave of 50 kilocycles which is impressed upon the harmonic producer H_1 adjusted to create therefrom the second and third harmonics, viz, waves of 100 and 150 kilocycles. If the filter F_3 is adjusted to pass a frequency of 100 kilocycles and the filter F_4 150 kilocycles, oscillations of the former frequency will be impressed upon the modulator M_1 and will therein beat with the incoming frequency of 750 kilocycles, producing two frequencies, 850 and 650 kilocycles, that is, the sum and the difference frequencies. If the filter F_2 is adjusted to pass only the difference frequency, viz, 650 kilocycles, oscillations of that frequency only will be impressed upon the amplifier A_1 and, when amplified, will be impressed upon the transmitting antenna TA_3 and radiated therefrom. Oscillations of this frequency will be impressed upon the receiving antenna RA_2 tuned for the reception of this frequency and will in turn be impressed upon the receiving circuit of the east station. This frequency, which is represented upon Fig. 3 by f_2, will not set up interfering oscillations in the receiving antenna RA_4 or in any of the receiving circuits if the frequency f_2 is sufficiently widely separated in the frequency spectrum from the frequency for which each antenna is tuned. In like manner the frequency f_4 transmitted by the antenna TA_2 of the east station will affect the antenna structure RA_4, which, as shown in Fig. 2, is intended to receive efficiently from the east, but to be substantially unaffected by waves of the same frequency from the west. The oscillations received by RA_4 will be modulated in the device M_2 by the third harmonic produced by the device H_1, which will be passed by the filter f_4 to the modulator M_2. Since the third harmonic is 150 kilocycles and the received oscillations are of the frequency of 750 kilocycles, the resultant oscillations produced by beating will be 900 and 600 kilocycles. If the filter F_6 is adapted to pass the difference frequency, viz, 600 kilocycles, oscillations of this frequency will be impressed upon the amplifier A_2 and, when amplified, will be transmitted by the antenna TA_4. These oscillations will, with the arrangement shown in the drawing, be radiated in all directions, but by tuning the receiving antenna RA_1 of the west station for the reception of this frequency, they will be received only by this station and will produce no interference in other receiving circuits. It will accordingly be seen that with the arrangement shown in the drawing and following the method outlined in this specification, two-way communication through a system employing two terminal stations and a single repeater station located therebetween may be accomplished by the use of three frequencies without creating any interference, that is, singing, of the repeater circuit itself, or between the repeater station and a terminal station.

The other diagrams 3^a, 4 and 4^a represent other modes of distribution of the frequencies throughout the system, but in any case the total number of frequencies involved does not exceed three. In Fig. 3^a, the frequency f_4 is received from both directions at the repeater station, and transmission to the west is accomplished over the frequency f_2 and to the east by the frequency f_3, which is opposite to the system of distribution shown in Fig. 3. In Fig. 4, the received frequency f_4 is between the frequencies transmitted from the repeater station, viz, transmission to the east is over the frequency f_2, which is below the frequency f_4, and transmission to the east is over the frequency f_3 which is above the received frequency f_4. To effect the system of distribution shown in Fig. 4, it is necessary to select the difference frequency resulting from modulation when transmitting to the east and to select the sum frequency resulting from demodulation when transmitting to the west. The arrangement shown in Fig. 4^a is simply the opposite of that shown in Fig. 4.

In the frequency distribution diagrams, Figs. 3 to 4^a inclusive, the frequency difference between f_3 and f_4 is not equal to the difference between f_2 and f_4. However, such inequality is not essential to the operation of the system. By the proper selection of the beat frequencies, these differences may be equalized. For example, in Fig. 4 if f_4 represents 750 kilocycles, by using the same harmonic of 50 kilocycles, as for example, 100 kilocycles and selecting in one case the sum and in the other case the difference frequency of modulation, that is 850 and 650 kilocycles, the difference between f_3 and f_4 will equal the difference between f_2 and f_4. Furthermore, by proper selection of the beat frequency the difference between f_2 and f_4 may be made equal to that between f_2 and f_3.

Fig. 1^a shows a modification of the means for producing the modulating frequencies at the repeater station. In Fig. 1, there is shown a local source of oscillations O_1. In the arrangement shown in Fig. 1^a a separate antenna is provided tuned for the reception of a fundamental frequency f_1, which may be transmitted, for example, from one of the terminal stations. From this fundamental frequency, the requisite harmonics would be produced by the device H_1.

It is desired to clearly set forth that while reference has been made throughout the description of my invention of the use of a single frequency, as, for example, f_2 or f_3, as representing the transmitted or received frequencies constituting a transmission channel, it is to be understood that the designation of these channels by single frequency waves is for the purpose of rendering the description simple and therefore clear, but it is not to be construed as limiting the invention in any way to transmission or reception upon a single frequency. The transmitted and the received waves of each channel may, of course, be a side band of frequencies produced by the modulation of a carrier frequency by the frequencies within the voice range, such as is done in radio telephony, or by the modulation of a carrier frequency by telegraph frequencies, such as is employed in radio telegraphy.

While this invention has been disclosed as embodied in a particular form and arrangement of parts, it is not so limited but is capable of embodiment in other forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a radio repeating system having terminal stations and a single repeater station located therebetween in which two-way signaling is effected by using at each terminal station a transmitting wave of different frequency from the receiving wave, the method of limiting to three the number of frequencies used throughout the system for each channel of communication which consists in selectively receiving at the repeater station east and west waves of the same frequency simultaneously, changing the frequency of both of the received waves, and transmitting the waves of changed frequency.

2. In a radio repeating system having terminal stations and a single repeater station located therebetween in which two-way signaling is effected by using at each terminal station a transmitting wave of different frequency from the receiving wave, the method for limiting to three the number of frequencies used throughout the system for each channel of communication which consists in selectively receiving at the repeater station east and west waves of the same frequency, changing the frequency of one wave by an amount differing from that by which the other wave is changed, and transmitting the waves of changed frequency.

3. In a radio repeating system having terminal stations and a single repeater station located therebetween in which two-way signaling is effected by using at each terminal station a transmitting wave of different frequency from the receiving wave, the method for limiting to three the number of frequencies used throughout the system for each channel of communication which consists in selectively receiving east and west waves of the same frequency, creating a modulating frequency, producing harmonics of the modulating frequency, beating one of the received waves with one of the harmonics, and selecting one of the frequencies resulting from demodulation, beating the other received wave with the other harmonic, and selecting one of the frequencies resulting from demodulation and transmitting both selected frequencies.

4. In a radio repeating system having terminal stations and a single repeater station located therebetween in which two-way signaling is effected by using at each terminal station a transmitting wave of different frequency from the receiving wave, the method for limiting to three the number of frequencies used throughout the system for each channel of communication which consists in selectively receiving east and west waves of the same frequency, beating one of

the said waves with oscillations of a fixed frequency, and selecting one of the frequencies resulting from the said beating, beating the other of the said waves with oscillations of a second fixed frequency which is different from the first fixed frequency, selecting one of the frequencies resulting from the said beating and transmitting both of the selected frequencies.

In testimony whereof, I have signed my name to this specification this 20th day of March, 1924.

DE LOSS K. MARTIN.