Nov. 23, 1926. 1,607,837

DE LOSS K. MARTIN

RADIO REPEATER SYSTEM

Filed March 22, 1924

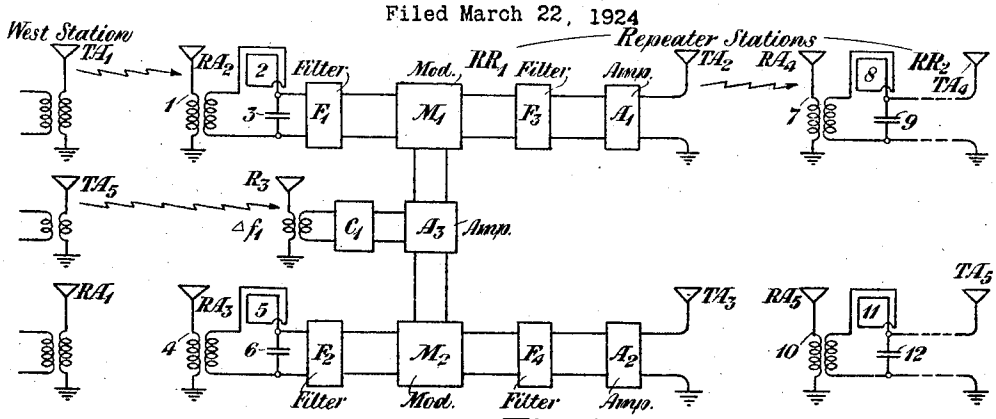


Fig. 1

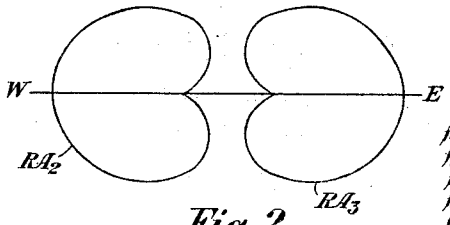


Fig. 2

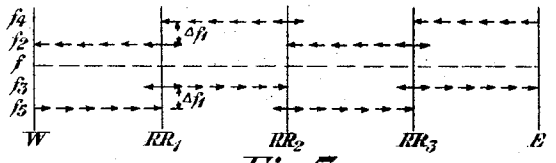


Fig. 3

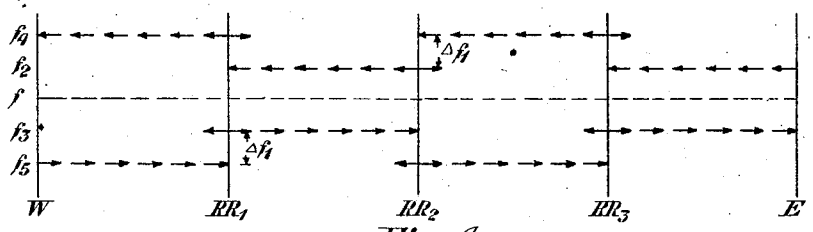


Fig. 4

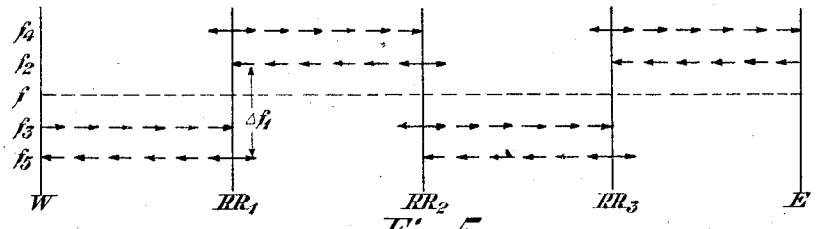


Fig. 5

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UNITED STATES PATENT OFFICE.

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RADIO REPEATER SYSTEM.

Application filed March 22, 1924. Serial No. 701,188.

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

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. If two or more repeaters are included in such a system, the number of frequencies required for the system will, in general, be increased two per channel for each repeater. Obviously, the large demand made upon the frequency spectrum by such a system greatly reduces the field of use of radio repeaters. The applicant has found that by the use of means for controlling the direction of transmission and the reception of waves of the various frequencies and means for changing and selecting the frequencies, it is possible to greatly reduce the number of frequencies required by a multi-repeater radio system below the number given above, namely, two per channel per repeater.

In my copending application, Serial No. 701,186 filed March 22, 1924, I disclose a method and means for operating a radio communication system involving the use of repeaters, in which system the number of frequencies per channel of communication does not exceed four, regardless of the number of repeaters involved. The system disclosed in the said copending application is characterized by the recepton at any repeater station of waves from both directions at different frequencies, and by transmitting therefrom in both directions at different frequencies the reception frequencies lying within one side band of a controlling carrier frequency and the transmtting frequencies lying within the opposite side band of that carrier frequency.

The object of the present invention is to provide a method for operating a two-way radio communication system involving a plurality of repeaters, in which the number of frequencies per channel of communication does not exceed four, regardless of the number of repeaters involved, which method is characterized by reception at any repeater station from opposite directions at different frequencies; and for transmitting from that repeater station in opposite directions also at different frequencies, the received waves lying within opposite side bands of a fictitious carrier frequency and the transmitted waves likewise lying within opposite side bands of that same carrier frequency.

The invention will be clearly understood from the following description when read in connection with the attached drawing, of which Figure 1 shows schematically one form of embodiment of the invention, Fig. 2 shows directional characteristics of the receiving antennæ of a repeater station, and Figs. 3 to 5 inclusive represent various

methods of frequency distribution throughout a system employing the apparatus shown in Fig. 1.

Fig. 1 shows primarily the circuit arrangement in schematic form of one of the repeater stations as for example, RR_1 indicated upon the frequency distribution charts shown in Figs. 3 to 5 inclusive; and incidentally, the west terminal station and also part of the receiving circuit of the adjacent repeater station RR_2. The west station, which may be of any well known type, comprises a transmitting antenna TA_1, adapted to transmit, for example, the frequency f_5 of Fig. 3. It may also be designed and adjusted to transmit a frequency $\triangle f_1$, which latter frequency is used for modulating the signaling frequencies at the repeater stations. It may be preferable to provide a separate transmitting antenna in connection with the system for transmitting this modulating frequency and such an antenna is shown in Fig. 1 by TA_5, or $\triangle f_1$ may be supplied locally at each repeater by means of an oscillator generating the frequency $\triangle f_1$. The west station also comprises a receiving antenna RA_1, which is designed and adjusted for the reception of signals coming from the east. It is to be understood that the terms "east" and "west" have been chosen arbitrarily to describe this invention and constitute no limitation therein.

At the radio repeating station RR_1 each of the receiving antennæ RA_2 and RA_3 is designed and adjusted in ways well known to those skilled in the art for receiving signals efficiently from one direction only. It is well known that an antenna structure comprising a vertical antenna, such as 1 and a loop such as 2, may have directional characteristics, such as shown in Fig. 2. That is to say, 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 in Fig. 2. For example, the antenna RA_2 may be adjusted to receive efficiently from the west; that is to say, signals of the frequency f_5 transmitted by the antenna TA_1 and the antenna structure RA_3 may, in like manner, be adjusted to receive efficiently from the east, that is to say, the frequency f_3 transmitted from one of the transmitting antennæ associated with the repeater RR_2, which repeater should preferably be similar in arrangement to the repeater RR_1. By means of the condensers 3 and 6 the loops 2 and 5 may be properly tuned for the frequencies that they are to receive. M_1 and M_2 are modulators in which the received signaling frequencies are beaten with another frequency, which may be termed the modulating frequency received from the antenna TA_5. A controlling device C adjusts the frequency, if necessary, that is to be applied to the modulating devices and an amplifier A_3 amplifies this modulating frequency before impressing it upon the modulators. F_1, F_2, F_3 and F_4 are filters for selecting the frequencies that are intended to pass through these translating circuits. A_1 and A_2 are amplifiers whose output sides are connected with the transmitting antennæ TA_2 and TA_3 respectively. The antenna TA_2 transmits the frequency selected by the filter F_3 to the receiving antenna structure RA_1 of the repeater RR_2. The transmitting antenna TA_3 is intended to transmit the frequency selected by the filter F_4 to the receiving antenna RA_1 connected with the west terminal station.

Figs. 3, 4 and 5 represent different ways of distributing the frequencies throughout a communication system, such as is shown schematically in Fig. 1, which will prevent singing at the repeaters or between a repeater and a terminal station. In Figs. 3 and 4, the frequencies received at each repeater station are translated a definite frequency interval within the same side band and are then transmitted. In Fig. 5, the received frequencies are translated a definite frequency interval $\triangle f_1$ into the opposite side band of a fictitious carrier frequency f. The method of operating the system of Fig. 1 in order to carry out the method shown in Fig. 3 is as follows: The frequency f_5 would be transmitted by the antenna TA_1 to the receiving antenna RA_2, which would be adjusted to have the reception characteristic shown by the left-hand diagram of Fig. 2. This characteristic indicates good reception from the left, that is, from the west terminal station, and substantially zero reception from the east. The received frequency would be passed by the filter F_1 and impressed upon the modulator M_1. Simultaneous with the reception of this signaling frequency, the modulating frequency $\triangle f_1$ would be transmitted by TA_5 and received by the antenna RA_3. This frequency would be amplified by the amplifier A_3 and impressed upon the modulator M_1. Of the products of modulation, one frequency, namely, f_3 would be selected by the filter F_3 and impressed upon the amplifier A_1. This frequency, when amplified, would be transmitted by the antenna TA_2. The transmitted frequency f_3 would be received by the antenna RA_1 of the repeater RR_2 and would be translated therein as shown in Fig. 3 to produce the frequency f_5, which would be radiated from a similar antenna as TA_2. In transmitting from the east terminal station to the west, waves of the frequency f_4 would be impressed upon the receiving antenna RA_3 and would be passed by the filter F_2 to the modulator M_2. Herein they would be beaten with the frequency

$\triangle f_1$, and of the products of modulation one of the frequencies, namely, f_2 would be selected by the filter F_4 and amplified by the amplifier A_2. This frequency would then be transmitted by the antenna TA_3 and would be received by the antenna RA_1 of the west terminal station. By making the difference frequency $\triangle f_1$ sufficiently large, the transmitted frequency at any repeater will not enter the receiving circuit at that station and consequently, singing thereat will be prevented. Furthermore, singing is prevented by the use of direction-controlled receiving antennæ at the various stations, which discriminate against waves coming from directions other than that for which they are designed to be selective. The distribution in Fig. 4 differs from that in Fig. 3 in that, for example, at the repeater RR_1 the frequency transmitted to the west is more widely separated from the frequency received from the west than in Fig. 3. In Fig. 5 the received frequency f_2 is translated by an amount $\triangle f_1$ to produce the frequency f_5 for transmission therefrom, the frequency f_5 lying within the opposite side band of the fictitious carrier frequency f to that side band in which the frequency f_2 lies. In like manner, the received frequency f_3 is translated by the amount $\triangle f_1$ to produce the frequency f_4 for transmission. It will be seen, therefore, that by means of the arrangement shown in Fig. 1, operated in accordance with the frequency distribution shown in Figs. 3 to 5 inclusive, a two-way communication channel may be established in a system employing a plurality of repeaters which does not require more than four frequencies per channel of communication, irrespective of the number of repeaters, and which is substantially free from singing.

While this invention has been disclosed as embodied in a particular form it is obvious that it 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 plurality of repeater stations located therebetween in which two-way signaling is effected by using at each repeater station a transmitting wave of different frequency from the received wave, the method for limiting the number of frequencies used throughout the system for each channel of communication to four regardless of the number of repeaters involved, which consists in receiving by directionally selecting at each repeater station east and west waves of different frequencies, translating each of the said frequencies by the same amount and transmitting each of the said waves as thus changed.

2. In a radio repeating system having terminal stations and a plurality of repeater stations located therebetween in which two way signaling is effected by using at each repeater station a transmitting wave of different frequency from the received wave, the method for limiting the number of frequencies used throughout the system for each channel of communication to four regardless of the number of repeaters involved, which consists in receiving by directionally selecting at each repeater station east and west waves of different frequencies, receiving a carrier frequency, beating each of the received frequencies by the said carrier frequency, and selecting one side band of each received wave as thus beaten, and transmitting each of the side bands as thus selected, the said beating frequency being so chosen that the sum of the said carrier frequency and the lower received frequency will be less than the difference of the carrier and the higher received frequency.

3. In a radio repeating system, the combination with a plurality of terminal stations of a repeater station comprising two directive receiving antennæ adjusted to receive from relatively opposite directions, a plurality of transmitting antennæ and a plurality of translating circuits, each connecting one receiving antenna with one of the transmitting antennæ, each translating circuit including a modulator interposed between a plurality of filters, a third receiving antenna adapted to receive a beating frequency, and means to apply the said beating frequency to the modulators of each of said translating circuits in order to demodulate the received frequencies present in each of the translating circuits.

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

DE LOSS K. MARTIN.