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RADIO REPEATER

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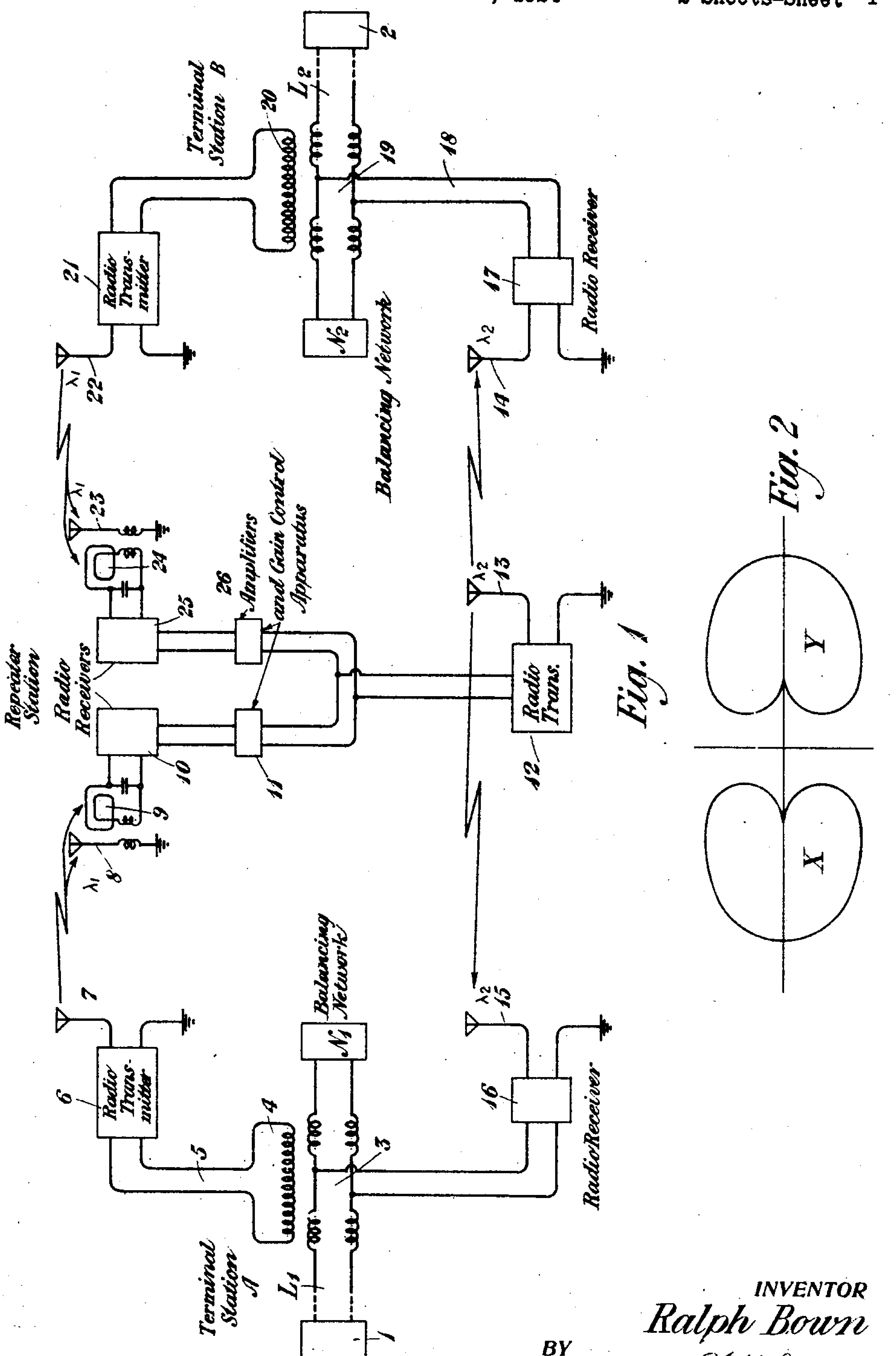

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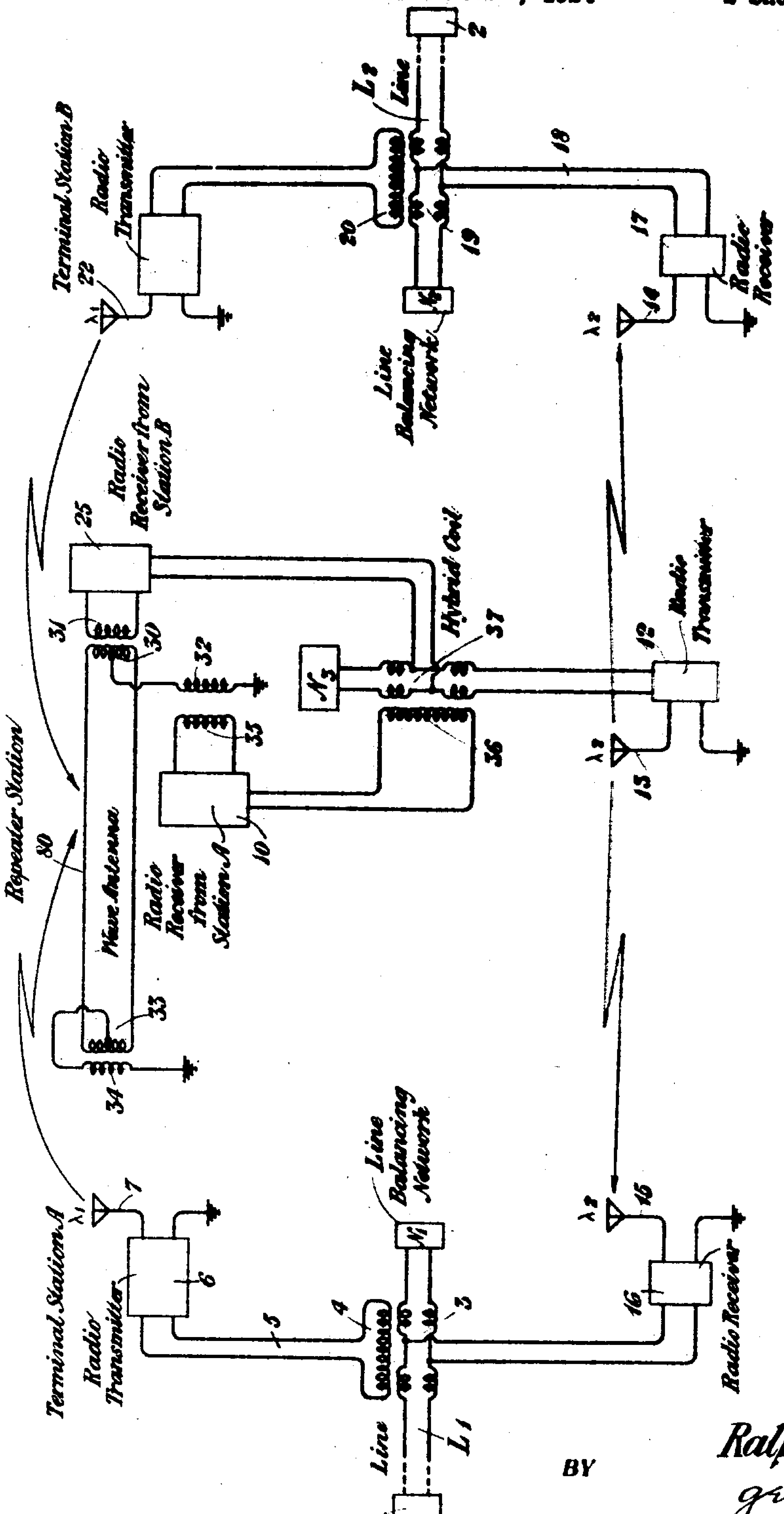

Fig. 3

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UNITED STATES PATENT OFFICE.

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RADIOREPEATER.

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This invention relates to radio repeater systems, and particularly to a system of that type characterized by undirectional reception at the repeater station and having separate receiving circuits, each of the latter having gain control devices whereby the transmission level of the oppositely directed channels may be separately controlled, the said system being further characterized by a single antenna structure for transmitting both channels.

Various types of radio repeaters have been devised, one of which, known as the 22-type, embraces, in fact, two complete transmitting and receiving stations. One station receives, for example, from the west and transmits to the east and the other operates only in the opposite manner. A repeater system of that type requires, in the most general case, the use of four channels or frequency bands in order to effect east and west two-way transmission without interference. Such a system is, however, expensive to install and operate and is also open to other criticism. It possesses, however, by virtue of the use of separate transmitting and receiving apparatus for the oppositely traveling waves, the advantage that the said oppositely traveling waves may be separately amplified to a degree depending upon the transmission losses of the separate waves.

Another type of repeater, known as the 21-type, employs only a single transmitting and receiving station and utilizes two channels. Both the east bound and west bound signaling waves come to a single receiver upon the same carrier frequency, and both waves are repeated from the same transmitter at the same carrier frequency, the transmitting frequency, however, being different from the received carried frequency. While such a system is simple and cheap it has certain transmission defects which limit its usefulness, the principal one of which is that the repeater, having no flexibility of adjustment, amplifies equally both the eastbound and the westbound signaling waves.

The object of my invention is to provide a 21-type repeater with independent unidirectional receiving systems so that two incoming messages on the same wave length, but from different directions, may be received separately and each may be brought to any desired relative or absolute transmission level before they are reradiated from a common transmitting circuit.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing of which Figure 1 shows schematically one form of the embodiment of the invention employing unidirectional receiving antennæ of the combined vertical and loop type; Fig. 2 shows the characteristics of the receiving antennæ; and Fig. 3 shows a system employing a wave antenna, the receiving characteristics of which are as shown in Fig. 2.

In Fig. 1 is disclosed a system employing two terminal stations A and B and a single repeater station located therebetween. At the left the line L_1 connects the signaling apparatus 1, which may be a subscriber's telephone set, with the terminal station A, the connection being effected by means of the hybrid coil 3. The network N_1 connected with the hybrid coil 3 balances the line L_1. In similar manner, the line L_2 connects the telephone set 2 with the terminal station B, the connection being effected by means of the hybrid coil 19 to which is also connected the network N_2 to balance the line L_2. The hybrid coil 3 sometimes known as a three-winding transformer has windings connected with the line and also with the network and another winding 4 connected by the circuit 5 with the radio transmitter 6. The radio transmitter may be of any well known type comprising a source of carrier current whose wave length is λ_1 and means to modulate this carrier current with the signaling currents impressed upon the radio transmitter by the hybrid coil. This transmitter may also include one or more stages of amplification and may have selective means such as the Campbell wave filter. The radio transmitter 6 is connected with the antenna 7 which need not be of a unidirectional type. The receiving branch of this terminal circuit comprises an antenna 15, which need not be of a unidirectional type, and a radio receiver having its input side connected with the said antenna, and its output side connected with the hybrid coil 3 in the manner shown. The antenna 15 is designed and adjusted to receive signals of the wave length λ_2, and the radio receiver may be of any well known type adapted to demodulate the received high frequency signaling currents and to impress the low frequency component upon the line L_1 through the medium of the hybrid coil. Such a type of receiver would preferably have one or more stages of amplification and also selective devices.

The repeater station embraces separate receiving circuits and a common transmitting circuit. The receiving circuit for the waves transmitted from antenna 7 comprises a unidirectional antenna structure consisting of a vertical antenna 8 coupled with a loop antenna 9, which structure is connected with the radio receiver 10. The reception characteristic of this antenna is represented by X of Fig. 2. The form of radio receiver used may be that in which the incoming frequency is beaten down to a lower level before being impressed upon the amplifier and gain control apparatus 11. By means of the device 11 the required degree of amplification may be given to the received waves, and they may then be impressed upon the radio transmitter 12 wherein they are beaten to produce a frequency corresponding to the wave length λ_2 and are transmitted by the antenna 13. Since the antenna 13 is not directive, these waves will affect both antenna 15 at station A and antenna 14 at station B. The resultant incoming waves at station A will be impressed upon the line L, and will be heard as a sidetone by the subscriber at station 1. The transmitted waves received by antenna 14 will be impressed upon the radio receiver 17, and after demodulation, and preferably amplification, will be impressed by the circuit 18 upon the line L_2 through the hybrid coil 19 and will be heard by the subscriber at station 2.

The repeater station also comprises a directional antenna structure consisting of the vertical antenna 23 and the loop antenna 24, which structure is connected with the radio receiver 25. This antenna structure is designed to have the characteristic Y of Fig. 2 which shows maximum receptivity from the right-hand direction, that is, from the station B. The radio receiver 25 is connected with the amplifier and gain control apparatus 26 whereby the requisite amplification may be given to the signals received from station B before impressing them upon the radio transmitter 12 to be radiated from the antenna 13.

From the foregoing description it will be seen that speech signals impressed upon the line L_1 by the apparatus 1 will modulate carrier currents of the wave length λ_1 by means of the radio transmitter 6, and the modulated waves will be radiated by the antenna 7. These high frequency waves as thus modulated will be received by the antenna structure 8—9, and will be beaten with another frequency within the radio receiver 10. One of the resultant frequencies or bands will be selected and given the requisite amplification by means of the device 11. This will be impressed upon the radio transmitter 12 and will therein be beaten with another frequency, so that one of the resultant frequencies will correspond to the transmitting wave lengh λ_2. This wave length, modulated by the speech currents, will be transmitted by the antenna 13 and will affect antennæ 14 and 15 in the manner referred to above. That which affects antenna 15 will be demodulated by the receiver 16, and the speech current will flow over the line L_1 to the station 1 appearing therein as a side tone effect, and the part affecting antenna 14 will be demodulated by the receiver 17, and the speech component will be transmitted by the line L_2 to station 2. The speech currents set up at station 2 will be conveyed by the line L_2 to the station B and will be impressed upon the radio transmitter 21 serving therein to modulate the carrier current corresponding to the wave length λ_1. This carrier current, as thus modulated, will be radiated from the antenna 22 and will affect the antenna structure 23—24 but will produce no substantial effect upon the antenna structure 8—9 because the latter receives only slightly from the direction of terminal station B. The modulated waves from the structure 23—24 will be demodulated by the radio receiver 25 and impressed upon the amplifier 26 wherein it will be given the necessary amplification, and the resultant amplified current will be impressed upon the radio transmitter 12. The resultant modulated high frequency current corresponding to the wave length λ_2 will be transmitted broadly, affecting antennæ 14 and 15. The part affecting antenna 14 produces a side tone effect at the subscriber station 2. The part affecting antenna 15 will be demodulated by the receiver 16, and the resultant low frequency current will reach the receiver of the subscriber station 1.

By using different transmitting and receiving wave lengths, the individual terminal circuits are prevented from singing. The tendency to sing is furthermore minimized by the use of the hybrid coil and the network at each terminal station to balance the line circuit connected therewith, and in like manner, the tendency of the repeater circuit to sing is reduced to a minimum. Although the same wave length has been employed in transmitting from stations A and B and also the same wave length in transmitting from the repeater station to both stations A and B, I am able to control the magnitude of amplification to be given to the oppositely traveling waves by using unidirectional receiving antennæ, each of which has its separate amplifying and gain controlling apparatus.

Another form of this invention is shown in Fig. 3. The structure of this figure differs from that of Fig. 1 principally in the use of a wave antenna instead of the combined vertical and loop antenna structure shown in Fig. 1. The same reference characters have been used in Fig. 3 to indicate parts similar to those shown in Fig. 1. Since the terminal stations are similar to those shown in Fig. 1 the description of the apparatus will be limited to the repeater station. The antenna 80, which receives independently from two opposite directions upon the same wave length, is described in a paper by Beverage, et al., entitled "The wave antenna" published in the Journal of the American Institute of Electrical Engineers, Vol. XLII, Nos. 3, 4, 5 and 6. The form used by the applicant is substantially the same as that shown in Fig. 18 of the said paper. This antenna comprises two conductors connected with the outer terminals of the coils 30 and 33. The midpoint of coil 30 is connected to ground through the winding 32 which is coupled with the winding 35 connected with the input side of the radio receiver 10. Coil 33 has its midpoint connected to ground through coil 34 which is inductively connected with coil 33 so as to reflect the wave from the transformer 33—34 whenever current flows through coil 34 to ground. This constitutes the "reflection transformer" described by Beverage at page 264 of the paper cited above. Coil 30 is coupled with coil 31 which is connected with the input side of the radio receiver 25. As will be clear from a later description, radio receiver 10 receives, detects and amplifies to the required degree the waves transmitted from station A and, in like manner, radio receiver 25 affects those waves transmitted from station B. The output sides of both of these radio receivers are connected with the hybrid coil 37 which is connected with the radio transmitter 12 and also with the network N_3, the purpose of which is to balance the transmitting circuit, including the radio transmitter 12 and the antenna 13. By means of the transmitter 12, the high frequency current is modulated by the currents impressed thereon by the radio receivers 10 and 25 in order to effect transmission of the latter currents to the receiving antennæ at stations A and B. The antenna 80 is so arranged that when the electromagnetic waves from station A are impressed thereon current will flow to ground from the two conductors thereof through the midpoint connections of coils 33 and 30. Since the current flows in opposite directions in coil 30, no effect will be produced thereby in coil 31 which is connected with the input side of the receiver 25. But the current flowing from the midpoint of coil 30 through coil 32 will produce an effect in coil 35 which will be impressed upon the radio receiver 10. This current will be demodulated either entirely, i. e., to produce a speech frequency, or partially to produce an intermediate frequency modulated by the speech frequency. Regardless of the extent of demodulation, the demodulation current will be amplified to the degree required in order to produce the proper transmission level for the transmitted wave. The amplified current will be impressed by winding 36 upon the hybrid coil 37 and will, in turn, be impressed upon the radio transmitter 12. Herein it will serve to modulate carrier frequency so as to produce a modulated high frequency current corresponding to the wave length λ_2. This will be radiated by the antenna 13 in both directions and will produce currents in the subscribers' sets connected with the lines L_1 and L_2. The wave transmitted from antenna 22 at station B will be reflected in the antenna 80 from the end connected with the coil 30 and will produce the maximum voltage at the end connected with coil 33. The effect thereof is to cause a circulation of current around the conductors and through the coils 30 and 33. This current will be impressed by coil 31 upon the radio receiver 25 but will not flow to ground through the branch containing coil 32. Consequently the waves transmitted from antenna 22 will not affect receiver 10 which is intended for operation only in connection with station A.

It will be seen, therefore, that by means of the arrangement shown in Fig. 3 the oppositely traveling waves may be given independent amplification, the degree of which depends upon the relative losses of the oppositely traveling waves. The arrangement is furthermore characterized by the use of a single antenna coupled with separate receiving circuits in such manner that each receiving circuit will not be affected by waves impressed upon the antenna from a direction other than from which they are intended to receive. The arrangement is also characterized by the use of the hybrid coil and balancing network of the repeater station whereby the undesired reaction between the two radio receivers is prevented.

While this invention has been disclosed as embodied in a particular form, it is to be understood that it is not so limited but may be embodied in other and different forms without departing from the spirit and scope of the appended claim.

What is claimed is:

In a radio repeater, the combination with a wave antenna having a reflection transformer connected thereto adapted for the bilateral reception of electromagnetic waves, of separate translating circuits connected with the said antenna in such manner that each will receive waves only from a predetermined direction, the said translating circuits having means to detect the received frequencies and to amplify them to the required degree, and a transmitting circuit common to the said translating circuits adapted to modulate the amplified currents and to transmit them.

In testimony whereof, I have signed my name to this specification this 7th day of November 1924.

RALPH BOWN.