Sept. 2, 1947. C. E. ATKINS 2,426,581

METHOD OF, AND APPARATUS FOR, CONCURRENT RADIO TRANSMISSION AND RECEPTION

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Fig. 1.

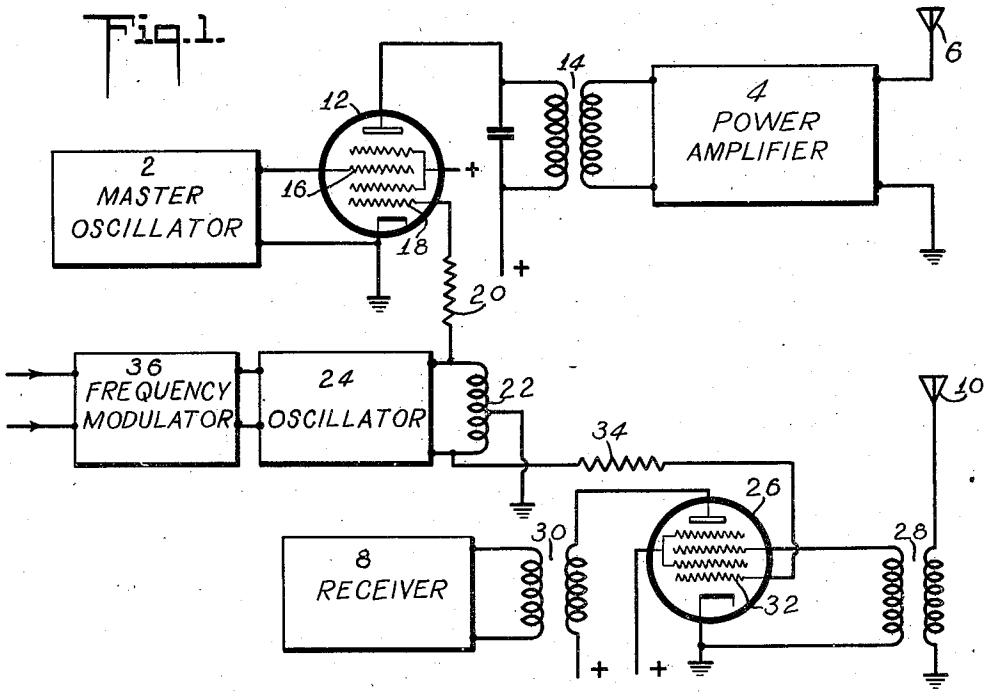
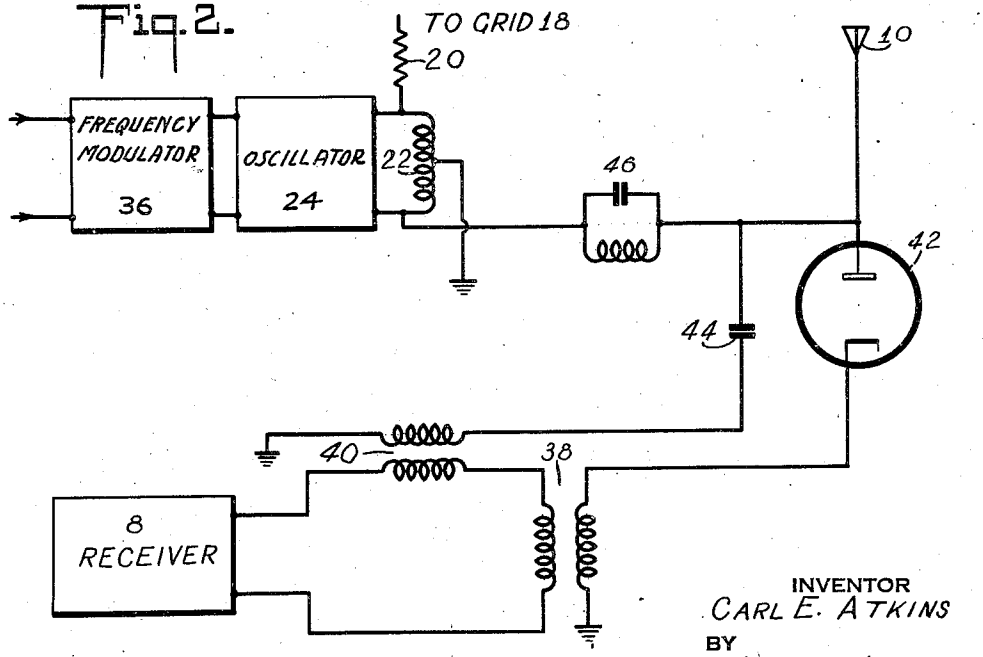


Fig. 2.



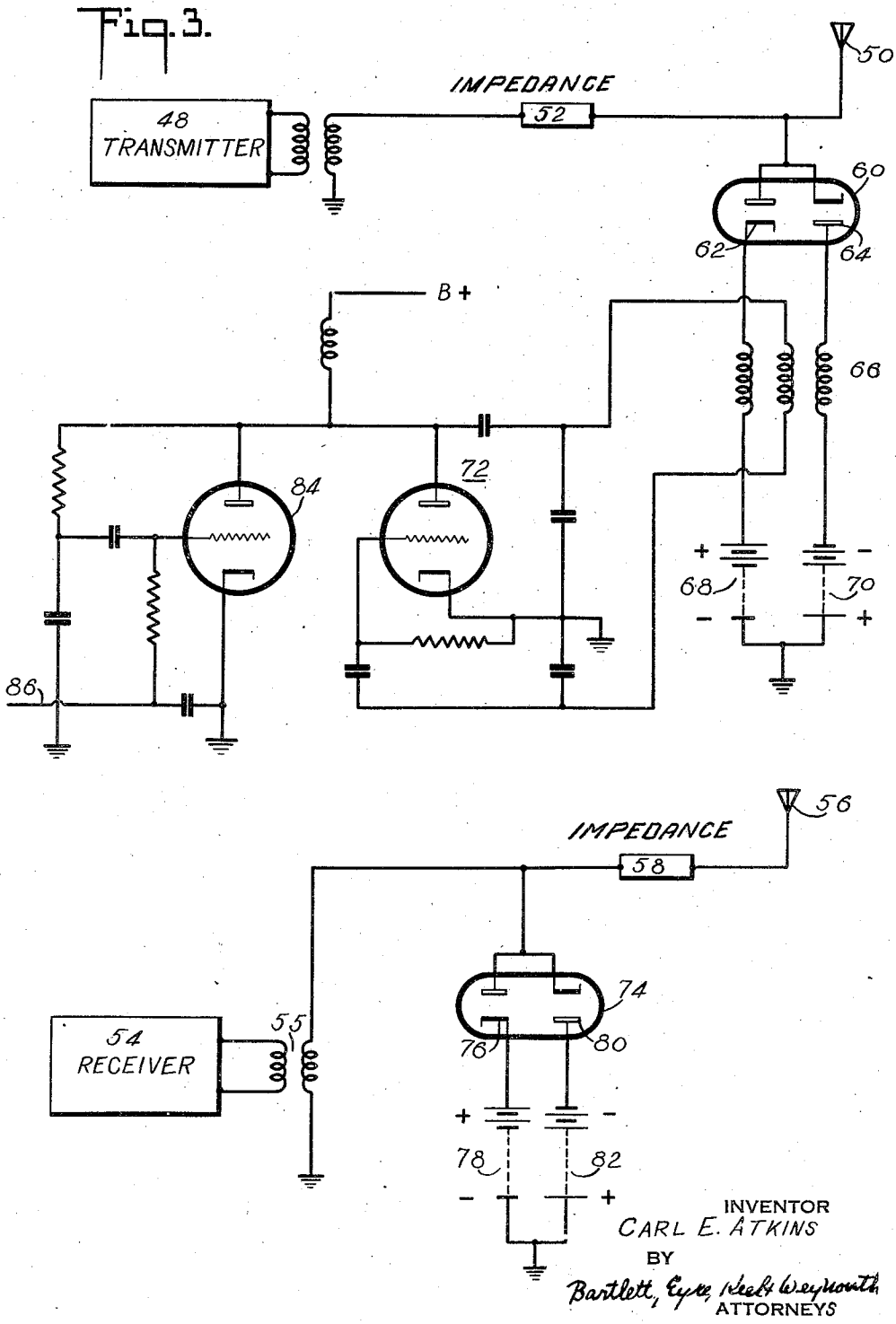
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Fig. 3.



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METHOD OF AND APPARATUS FOR CONCURRENT RADIO TRANSMISSION AND RECEPTION

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Application July 1, 1942, Serial No. 449,256

11 Claims. (Cl. 250—13)

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My present invention relates to radio communication and comprises a novel method of concurrent transmission and reception which makes possible the use of a receiver during radiation of energy from a neighboring high-powered transmitter, irrespective of the frequency of transmission and reception. The invention includes also novel apparatus for practicing the method.

In many cases it is necessary, or at least highly desirable, that receivers and transmitters be located near to each other and operated concurrently. To prevent the receiver from being overwhelmed by the abundance of energy from the transmitter and thus rendered unable to respond to relatively weak signals from a distant station, highly selective circuits have been employed and shielding means between the antennae have been provided. These arrangements, however, are effective only when the operating frequencies are far apart and hence in the ordinary operation of transceivers the transmitter portion of the equipment is shut off during reception.

The present invention which permits the concurrent use of both sending and receiving equipments, irrespective of the operating frequencies, permits of easy two-way communication between stations without requiring the shutting off of power to the transmitter during reception. The invention may be advantageously employed in any transceiver, but is of particular value in connection with the point-to-point secret signalling system disclosed and claimed in my copending application S. N. 443,898, filed May 21, 1942, wherein simultaneous transmission and reception are vital.

According to the invention, concurrent operation of the transmitter and receiver is obtained by alternately suppressing the transmission and reception of a transceiver at a superaudible rate whereby reception occurs only during the intervals of suppression of the transmitter. Because of the superaudible rate of interruption the periodic stopping and resuming of the transmitting and receiving functions do not impair the usefulness of either transmitter or receiver when used for the communication of audible intelligence between stations. Preferably the rate of interruption of the transmission and reception is varied in order to insure against the possibility that a distant station, with which communication is desired and which is similarly equipped for concurrent transmission and reception, might have its transmitter quenched at the same rate and in the same periods as that of the transmitter at the first station. In other words, if the rate of suppression were not varied, the periods during which a receiver at one point was operative to receive might be the same periods during which the transmitter at the other station was suppressed.

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For a better understanding of the invention, reference may be had to the accompanying drawings, of which

Fig. 1 is a diagrammatic circuit drawing illustrating one embodiment of the invention;

Fig. 2 is a modification of a portion of the circuit of Fig. 1; and

Fig. 3 is a diagrammatic circuit drawing illustrating another embodiment of the invention.

In Fig. 1 a transmitter is diagrammatically illustrated as including a master oscillator 2 and a power amplifier 4 connected to the transmitting antenna 6 and a receiver is diagrammatically illustrated at 8 coupled through a buffer stage hereinafter described to a receiving antenna 10. In the transmitter the output of the master-oscillator 2 is coupled to the power amplifier 4 through a buffer stage, consisting of a multielement tube 12 and coupling transformer 14. One grid 16 of tube 12 is connected to the master oscillator and serves to control the electron stream at a radio frequency rate, while a second control grid 18 of the tube 12 is connected through a resistor 20 to one side of a center-grounded coil 22 connected across the output terminals of an oscillator unit 24. Oscillator 24 serves to apply an alternating potential across coil 22 of a frequency substantially above audibility but low in comparison to the radio frequency used for signalling. Oscillator 24 may be, for example, a 50 kilocycle oscillator. During negative half cycles of the oscillator output the potentials applied to grid 18 will completely cut off the electron current through tube 12, thus rendering the tube inoperative to pass radio frequency energy from the master oscillator 2. During positive half cycles, however, tube 12 becomes operative and accordingly radio frequency energy is passed through the power amplifier 4 to antenna 6 during this interval. Resistor 20 serves to limit the current drawn by grid 18 of tube 12 during the positive half cycles of the oscillator output.

The buffer stage between the receiver 8 and antenna 10 includes a multielement tube 26, the input of which is coupled to antenna 10 by a transformer 28 and the output of which is coupled to the receiver 8 by a transformer 30. A grid 32 of tube 26 is connected through a grid current limiting resistor 34 with the end of coil 22 opposite to that to which grid 18 of tube 12 is connected. With this arrangement the potential on grid 32 of

tube 26 will be substantially 180 degrees out of phase with that on grid 18 of tube 12 and consequently the tube 26 will function to pass energy from antenna 10 to receiver 8 only during the intervals when the transmitting antenna 6 is quiescent.

With the above described arrangement, the transmitter and receiver will each be alternately operated and suppressed at a rate corresponding to the supersonic frequency of oscillator 24. As heretofore indicated, this rate should be varied to insure communication with other stations similarly equipped and utilizing the same rate of transmitter interruption. Any suitable means for varying the frequency of oscillator 24, as for example a reactance tube, may be provided. In Fig. 1, such frequency modulating means are indicated diagrammatically at 36.

In Fig. 2, an alternative arrangement for interrupting the reception is illustrated. In this drawing the transmitting portion of the equipment has not been illustrated as it may be identical with that of Fig. 1. In Fig. 2, the receiver 8 is fed from series-connected secondary windings of a pair of transformers 38 and 40, the primaries of which are in parallel ground circuits of the antenna 10. The windings of transformers 38 and 40 are so polarized as to introduce secondary potentials that are 180 degrees out of phase. The primary of transformer 38 is connected to antenna 10 through a diode 42 while the primary of transformer 40 connects to the antenna 10 through a condenser 44 having a small capacity substantially equal to that of the diode 42 when non-conducting. The end of coil 22 remote from that connected to the grid of the transmitter control tube is connected through a wave trap 46 with condenser 44 and diode 42. Wave trap 46 is tuned to the receiving frequency and serves to keep the signal energy out of coil 22 while allowing for the passage of the supersonic quenching potential in the other direction.

With the above described apparatus, equal currents will flow from antenna 10 through the primaries of transformers 38 and 40 during the half cycle when negative potentials are impressed from coil 22, and these equal currents will induce equal and opposite potentials in the secondaries of the transformers with the result that no voltage will be impressed across the receiver terminals. During the positive half cycles, however, diode 42 becomes conducting, hence the primary current through transformer 38 becomes larger than that through the primary of transformer 40 and accordingly a net secondary voltage, applicable to receiver 8, results.

In the embodiment of the invention diagrammatically illustrated in Fig. 1 and in the modification disclosed in Fig. 2, the control device is incorporated in the design of the transmitter-receiver apparatus. In Fig. 3 is illustrated an arrangement in which a control device embodying the invention is added to existing equipment. In the circuit of Fig. 3, a transmitter 48, of any suitable design, is transformer coupled to the transmitting antenna 50 through a series impedance 52 and a receiver 54, also of any suitable design, is similarly coupled by a transformer 55 with the receiving antenna 56 through a series impedance 58. Impedance 52 may be a reactance designed to match the antenna characteristic and impedance 58 may be a wave trap tuned to the transmitter frequency. In the event the receiver is to operate at the same frequency as the transmitter, impedance 58 may be merely a high inductance normally offering a slight impedance to the frequency of the signal from the antenna 56. A double diode 60 such as the 6H6 has one plate and one cathode connected in parallel to the antenna 50, the other cathode 62 and anode 64 being connected to ground through different windings of a three winding radio frequency transformer 66. Separate batteries 68 and 70 are inserted in the leads between the transformer windings and ground with the polarity of the batteries 68 and 70 such as to impress a positive potential with respect to ground upon cathode 62 and a negative potential with respect to ground upon anode 64. Thus the diode pair is ordinarily non-conducting for all normal values of radio frequency voltage appearing between the transmitting antenna 50 and the ground. In order to make the double diode conducting at supersonic intervals, the third winding of the transformer 66 is connected in the tank circuit of an oscillator indicated schematically at 72. The current through the third winding of the transformer 66 thus induces potentials on the cathode 62 and plate 64 of the diode pair 60 and these potentials are superimposed upon the radio frequency voltages from the antenna 50. During each peak of the oscillation the potentials induced on anode 64 and cathode 62 will be sufficient to overcome the bias of the batteries 70 and 68 and thus the double diode will become conducting and offer a low impedance path to ground from the transmitter. Thus during the peaks of oscillation, there will be an interruption of the energy radiated by antenna 50 and these interruptions, if the oscillator is properly designed, can be made to occur at a superaudible rate, for example 50 kilocycles.

Associated with the receiving apparatus is a double diode 74 having one anode and one cathode connected in parallel to the receiver side of impedance 58. Cathode 76 of double diode 74 is connected with the positive terminal of a battery 78 and anode 80 is connected with the negative terminal of a battery 82; the other terminals of batteries 78 and 82 being grounded. The potentials applied to cathode 76 and anode 80 by batteries 78 and 82, respectively, are such as to make the diodes non-conducting for very low levels of applied radio frequency potential. When the energy received by antenna 56 is great enough to cause voltages above this threshold value to be impressed across the double diode 74, it becomes conducting and provides practically a short circuit across the primary winding of transformer 55. Thus, during the intervals when the transmitting antenna 50 is radiating energy, enough of such energy will be picked up by antenna 56 as to cause the diode pair 74 to become conducting and to thus render the receiver 54 inoperative. Also, because of the by-passing of the transformer primary by the double diode 74 during such interval, such energy as is picked up by the receiver will be insufficient to overload the equipment. During the intervals when the transmitting antenna 50 is not radiating, diode pair 74 is non-conducting and the receiver 54 is free to receive weak signals from a distant point. Since this interchange of functions, as in the embodiments of the invention illustrated in Figs. 1 and 2, takes place at a superaudible rate, the periodic stopping and resuming of transmission and reception do not impair the usefulness of either transmitter or receiver when used for interchange of speech intelligence with a distant station. As heretofore indicated, it is advisable to vary the

superaudible rate of suppression of transmission and reception, in order to insure communication with a distant station similarly equipped and possibly having its transmitter suppressed at the same rate. In Fig. 3, this means for varying the rate of suppression of the transmitter, and hence of the receiver as well, is indicated as a reactance tube **84**, having its plate connected to the tank circuit of oscillator **72** and its control grid fed by signal energy of another superaudible frequency, as for example by 20 kilocycle energy introduced through a lead **86**.

From the above description it will be apparent that the invention provides a novel method for concurrent transmission and reception from adjacent transmitting and receiving apparatus without interference therebetween and provides novel apparatus for practicing the method; the method and the apparatus involving the intermittent suppression of the functioning of the transmitting and receiving equipment at a rate sufficiently high to avoid impairment of the use of the transmitting and receiving devices for communication of audible intelligence. Obviously various changes might be made in the circuits and elements of the control devices illustrated without departing from the spirit of the invention as defined in the accompanying claims. For example, double triodes could readily be substituted for the double diodes of Fig. 3 and other means could be devised for rendering the same conductive at supersonic intervals.

I claim:

1. The method of operating adjacent transmitting and receiving apparatus to permit concurrent operation thereof which comprises alternately suppressing transmission and reception at a superaudible rate and dynamically varying such rate of alternate suppression of transmission and reception at a different superaudible rate.

2. The method of operating adjacent transmitting and receiving apparatus which comprises intermittently suppressing transmission at a superaudible rate and utilizing energy delivered during the periods of transmission for suppressing reception.

3. The method of operating adjacent transmitting and receiving apparatus which comprises intermittently suppressing transmission at a superaudible rate and utilizing energy delivered during the periods of transmission for suppressing reception, the superaudible rate of suppression of transmission being varied at a different superaudible rate.

4. The combination with a transmitter and an adjacent receiver of means for generating a voltage of superaudible frequency, means controlled thereby for intermittently rendering said transmitter inoperative, and dynamic means for varying the superaudible frequency of the voltage generated by said first mentioned means at a different superaudible rate.

5. The combination with transmitting and adjacent receiving equipments each including an antenna, of an oscillator for generating voltage waves of superaudible frequencies, a center grounded inductor connected across the oscillator output, means associated with the transmitting equipment and connected with one end of said inductor for preventing flow of radio frequency energy to the transmitting antenna during alternate half cycles of the generated voltage wave, and means associated with the receiving equipment and connected to the other end of said inductor for permitting flow of radio frequency energy from the receiving antenna to the receiver portion of the equipment only during the same half cycle of the generated voltage.

6. The combination with transmitting and adjacent receiving equipments each including an antenna, of an oscillator for generating voltage waves of superaudible frequencies, a center grounded inductor connected across the oscillator output, means associated with the transmitting equipment and connected with one end of said inductor for preventing flow of radio frequency energy to the transmitting antenna during alternate half cycles of the generated voltage wave, means associated with the receiving equipment and connected to the other end of said inductor for permitting flow of radio frequency energy from the receiving antenna to the receiver portion of the equipment only during the same half cycle of the generated voltage, said last mentioned means including a pair of transformers having their secondaries connected in series and in opposite polarity across the input of the receiver portion of the equipment and their primaries connected in parallel to the receiving antenna and to said other end of said inductor, and a diode in series with one of said primaries arranged to become conducting during application of positive voltage from said oscillator whereby a net voltage applicable to the receiver is induced in the circuit of said secondaries during alternate half cycles of the generator voltage.

7. The combination with transmitting and adjacent receiving equipments each including an antenna, of an oscillator for generating voltage waves of superaudible frequencies, a center grounded inductor connected across the oscillator output, means associated with the transmitting equipment and connected with one end of said inductor for preventing flow of radio frequency energy to the transmitting antenna during alternate half cycles of the generated voltage wave, means associated with the receiving equipment and connected to the other end of said inductor for permitting flow of radio frequency energy from the receiving antenna to the receiver portion of the equipment only during the same half cycle of the generated voltage, and including means for varying the superaudible frequency of the voltage generated by said oscillator.

8. The combination with a transmitter having a transmitting antenna and an adjacent receiver having a receiving antenna, of a normally non-conducting device connected between the transmitting antenna and ground, an oscillator for generating a voltage wave of superaudible frequency, means in circuit with said device and responsive to the voltage generated by said oscillator for intermittently rendering said device conducting, and a second normally non-conducting device connected between the receiving antenna and ground, said last mentioned device being adapted to become conducting when energies above a threshold value appear at said receiving antenna whereby, when said transmitting antenna is radiating, energy picked up by said receiving antenna is by-passed about the receiver by the device associated with the receiving antenna and conversely, when the device associated with the transmitting antenna is rendered conducting by said oscillator so that energy is not radiated by said transmitting antenna, low level energy received by the receiving antenna is delivered to the receiver.

9. The combination with a transmitter having a transmitting antenna and an adjacent receiver

having a receiving antenna, of a normally non-conducting device connected between the transmitting antenna and ground, an oscillator for generating a voltage wave of superaudible frequency, means in circuit with said device and responsive to the voltage generated by said oscillator for intermittently rendering said device conducting, and a second normally non-conducting device connected between the receiving antenna and ground, said last mentioned device being adapted to become conducting when energies above a threshold value appear at said receiving antenna, whereby, when said transmitting antenna is radiating, energy picked up by said receiving antenna is by-passed about the receiver by the device associated with the receiving antenna and conversely, when the device associated with the transmitting antenna is rendered conducting by said oscillator so that energy is not radiated by said transmitting antenna, low level energy received by the receiving antenna is delivered to the receiver, and an impedance between the transmitter and the transmitting antenna and an impedance between the receiver and the receiving antenna, said first mentioned normally non-conducting device being connected to the antenna side of said first mentioned impedance and said second mentioned normally non-conducting device being connected to the receiver side of the last mentioned impedance.

10. The combination with a transmitter having a transmitting antenna and an adjacent receiver having a receiving antenna, of a normally non-conducting device connected between the transmitting antenna and ground, an oscillator for generating a voltage wave of superaudible frequency, means in circuit with said device and responsive to the voltage generated by said oscillator for intermittently rendering said device conducting, and a second normally non-conducting device connected between the receiving antenna and ground, said last mentioned device being adapted to become conducting when energies above a threshold value appear at said receiving antenna, whereby, when said transmitting antenna is radiating, energy picked up by said receiving antenna is by-passed about the receiver by the device associated with the receiving antenna and conversely, when the device associated with the transmitting antenna is rendered conducting by said oscillator so that energy is not radiated by said transmitting antenna, low level energy received by the receiving antenna is delivered to the receiver, each of said normally non-conducting devices comprising a double diode having a cathode of one pair of electrodes positively biased with respect to ground, an anode of

the other pair of electrodes negatively biased with respect to ground, and the remaining anode and cathode connected in parallel to the associated antenna.

11. The combination with a transmitter having a transmitting antenna and an adjacent receiver having a receiving antenna, of a normally non-conducting device connected between the transmitting antenna and ground, an oscillator for generating a voltage wave of superaudible frequency, means in circuit with said device and responsive to the voltage generated by said oscillator for intermittently rendering said device conducting, and a second normally non-conducting device connected between the receiving antenna and ground, said last mentioned device being adapted to become conducting when energies above a threshold value appear at said receiving antenna, whereby, when said transmitting antenna is radiating, energy picked up by said receiving antenna is by-passed about the receiver by the device associated with the receiving antenna and conversely, when the device associated with the transmitting antenna is rendered conducting by said oscillator so that energy is not radiated by said transmitting antenna, low level energy received by the receiving antenna is delivered to the receiver, including dynamic means for varying the frequency of the voltage wave generated by said oscillator at a superaudible rate.

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