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RADIO RELAYING SYSTEM

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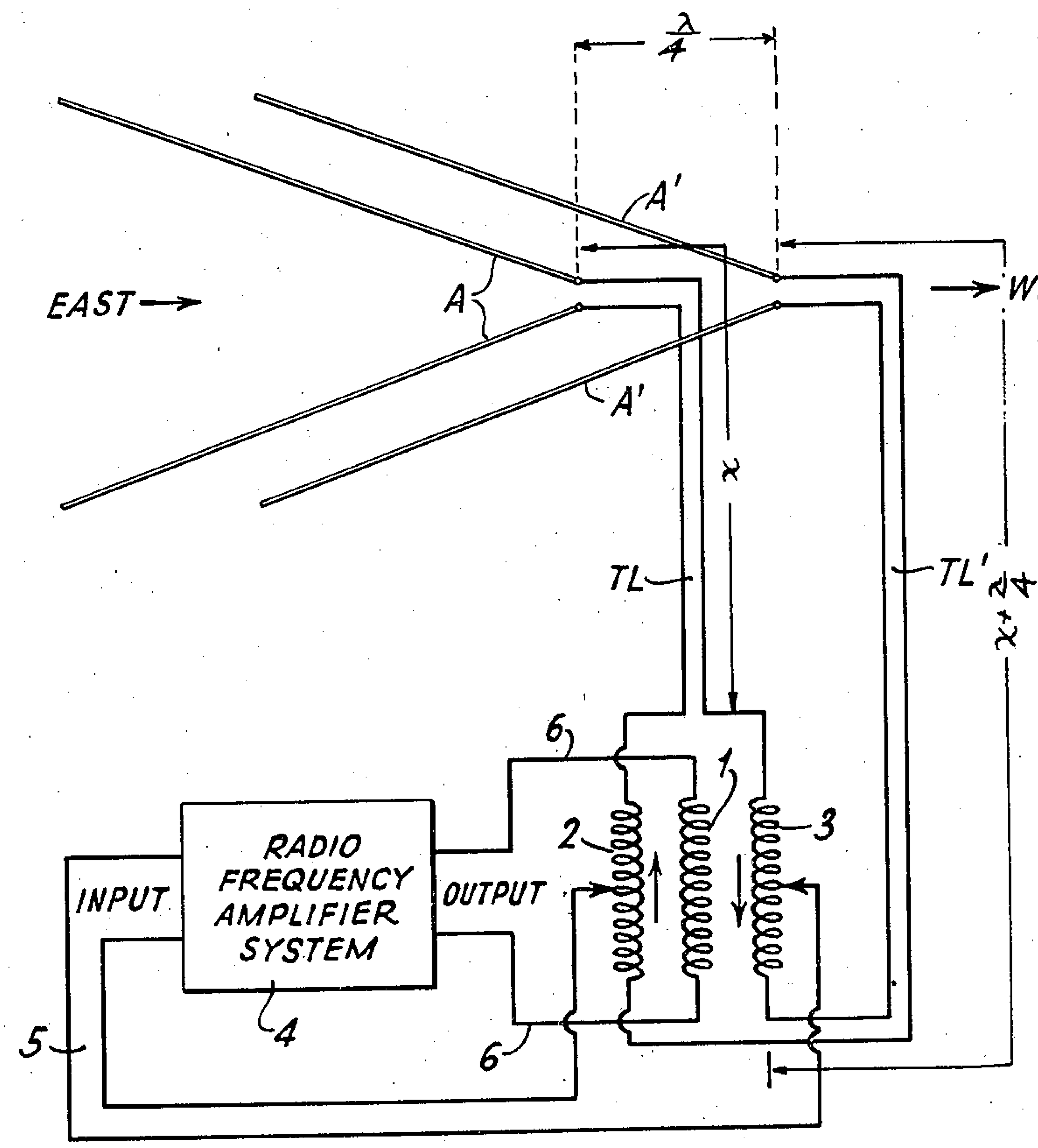

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RADIO RELAYING SYSTEM

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13 Claims. (Cl. 250—15)

This invention relates to improvements in radio relaying systems, and particularly to short wave radio relaying systems.

One of the objects of the present invention is to provide a radio relaying system capable of transmitting waves in the frequency band generally between 30 and 300 megacycles, which is efficient, occupies small space, and is relatively inexpensive to construct.

Another object of the invention is to provide a radio relaying system employing a pair of antennas which, although receiving signals on both antennas, is unidirectional so far as reception is concerned, and, although transmitting signals on the same pair of antennas, is unidirectional in a different direction, so far as transmission is concerned.

A further object is to provide a radio relaying system having a pair of antennas and an amplifier whose input is coupled to said antennas with like polarities and whose output is coupled to said antennas with unlike polarities, or vice versa.

A feature of the invention comprises the three coils which couple the two antennas of the relaying system to the amplifier, and the connections therebetween.

Other objects and features will appear from a reading of the following description which is accompanied by a drawing illustrating, by way of example only, a radio relaying system embodying the principles of the invention.

In the single figure of the drawing there is shown a radio relaying system, comprising two V antennas A, A' coupled by means of coils 1, 2 and 3 to a radio frequency amplifier 4. The amplifier contains frequency selective circuits for selectively amplifying a desired band of frequencies.

Antennas A, A' are bidirectional and of the type described in Philip S. Carter United States Patent No. 1,974,387, granted September 18, 1934; each comprising a pair of diverging conductors adapted to be energized with opposite instantaneous polarities and to be effective in a plane through the bisector of the angle of the V. The two antennas are symmetrically positioned relative to each other and spaced from each other along the bisector by a distance equal substantially to one-quarter of the length, or an odd multiple of one-quarter of the length, of the operating wave. Putting it another way, the spacing between antennas A and A' measured along the center line of their bidirectional beams, or in the desired direction of maximum radiation, is made substantially equal to a quarter wavelength, or an odd multiple of a quarter wavelength. The reference numeral "λ" indicated in the drawing represents the wavelength.

Both antennas A and A' are connected to the coupling coils 2 and 3 by transmission lines TL and TL', respectively, which differ in length from each other by one-quarter of the length of the operating wave, or, if desired, by an odd multiple of one-quarter of the operating wave. Lines TL, TL' have their characteristic impedances substantially matched by the effective input impedances of the antennas. Also, the coupling coils 2, 3 and 1 are preferably series tuned for the operating wave, each by means of two condensers symmetrically located with respect to the centers of the coils, and the coils are so adjusted and coupled with the amplifier and the transmission lines as to provide matching of the characteristic impedance of the lines, taking into account the effect of each line on the other.

Radio frequency amplifier 4 has its input leads 5 connected to the centers of coils 2 and 3, wound in reverse sense, and its output leads 6 coupled to the terminals of central coil 1, in turn coupled to both coils 2 and 3.

Let us assume that antenna A' is spaced from antenna A by one-quarter wavelength, and transmission line TL' is longer than line TL by one-quarter wavelength, and that signals arriving from the East are to be amplified and then transmitted toward the West. It will be obvious that the time phase relations between currents in similar parts of the two antennas are 90° different in phase. Due to the one-quarter wavelength spacing of the antennas and the one-quarter wavelength difference in length of the transmission lines, there is actually a one-half wavelength difference in phase relations in the energies received over the antennas as applied to the coils 2, 3. Because of this one-half wavelength difference, we can make the received energy arriving over one antenna either add to or oppose (i. e. buck) the energy received on the other antenna.

The transmission line circuit connections are arranged in the present invention so that signal energies arriving from the East and received on both antennas A and A' are supplied to input leads 5 in like phase from the ends of the lines TL, TL' terminating in the coils 2 and 3, thus making the input energies add. By reversing the sense of coupling of the coils 2 and 3, however, in the manner shown in the drawing, the amplified output energy from leads 6 is supplied to the same ends of the transmission lines in unlike or opposite phase, so that radiation continues to ward the West. The two arrows along coils 2 and 3 indicate that the relative phases of the output currents are reversed to produce radiation of signals from east to west. In other words, transmission lines TL and TL' are coupled to the input of the amplifier 4 in like polarity in order to obtain addition of input energies received over both antennas and arriving from one direction (east), while these same transmission lines TL, TL' are coupled to the output of the amplifier 4 in unlike polarity in order to have the amplified signals radiated from both antennas in the opposite direction (west). We thus have a unidirectional repeater or radio relaying system.

If signals from a distant transmitter pass the antennas in the wrong direction, from west to east, then the two transmission lines will bring currents to the amplifier input terminals which are of opposite phase and therefore tend to balance out so that they are amplified only feebly if at all. Most of the energy picked up returns to the antennas and is reradiated, or is absorbed in the amplifier output circuits without being amplified.

It will be apparent that the directions of reception and transmission of the whole relaying system can be reversed merely by reversing the connections to one transmission line, either at the antenna terminals or at the place where the lines are joined together, in which case the input of the amplifier will be coupled to the ends of the transmission lines in unlike polarity while the output of the amplifier will be coupled to the same ends of the transmission lines in like polarity.

Although the spacing between antennas has been mentioned as being one-quarter wavelength, it should be understood that this spacing may be any odd multiple thereof, and that the transmission lines may also differ in length by any odd multiple of one-quarter wavelength.. However, the spacing between antennas and the difference between lengths of transmission lines should not be excessive in magnitude, particularly if a wide percentage band width of current frequencies is to be relayed.

Due to the mutual coupling between the two antennas A and A', particularly if they are close together, they will ordinarily not deliver exactly equal energies at the terminals of the transmission lines, in the case of reception, nor will they require exactly equal energies in the case of transmission. This introduces some imperfection in the unidirectional receiving and transmitting characteristics of the system. It also tends to introduce coupling from the output circuit of the amplifier back into the input. This feedback coupling tends to cause oscillation of the radio frequency amplifier if the feed-back power is sufficiently great. Even though oscillation may take place, the system is capable of functioning satisfactorily for the relay of frequency modulated waves, so long as the received energy is capable of controlling the frequency of oscillation. In practice I contemplate adjusting the couplings from coil 1 to each half of each coil 2 and 3, and adjusting the taps of line 5 onto coils 2 and 3 until minimum feed-back from output to input of the amplifier, in the desired frequency band, is obtained. In this case there may be some undesired back radiation or reception, but this can be tolerated. Of course it is desirable to design the antennas for as little mutual coupling as possible consistent with other desired characteristics.

The coupling circuit transformers may be tuned to reduce the effects of leakage reactance. Also, the circuits may be made of sections of low impedance line, preferably about a half wave long each, use being made of the principles described and illustrated in my copending application Serial No. 199,421, filed April 1, 1938, which teaches how half wavelength low impedance lines can be employed for the same general purpose.

The amplifier 4 need not have a linear response characteristic if it is used to relay a frequency or phase modulated signal and, in fact, in this case some amplitude limiting in the amplifier is desirable.

The term "odd multiple of a quarter wavelength" used in the appended claims is intended to include any odd multiple, including unity.

What is claimed is:

1. A radio relaying system having a pair of antennas spaced apart from one another in the direction of transmission by an odd multiple of one-quarter the length of the operating wave, an amplifier, and individual transmission lines extending from said antennas toward said amplifier, said lines differing from each other by an odd multiple of one-quarter the length of the operating wave, and means for coupling the input of said amplifier to said transmission lines in like polarity and the output of said amplifier to said lines in unlike polarity.

2. A radio relaying system having a pair of antennas spaced apart from one another in the direction of transmission by an odd multiple of one-quarter the length of the operating wave, an amplifier, and individual transmission lines extending from said antennas toward said amplifier, said lines differing from each other by an odd multiple of one-quarter the length of the operating wave, and means for coupling the output of said amplifier to said transmission lines in like polarity and the input of said amplifier to said lines in unlike polarity.

3. A radio relay system having two antennas spaced apart in the direction of transmission by an odd multiple of one-quarter the length of the operating wave, an amplifier having an input circuit and an output circuit, individual transmission lines extending from said antennas toward said amplifier, said lines differing from each other by an odd multiple of one-quarter the length of the operating wave, and means for coupling one of said circuits of said amplifier to said transmission lines in like polarity, and the other circuit to said transmission lines in unlike polarity.

4. A radio relaying system for receiving signal energy from one direction and for transmitting amplified signal energy in a different direction, comprising a pair of bidirectional antennas spaced apart in the direction of transmission by an odd multiple of one-quarter the length of the operating wave, an amplifier having an input circuit and an output circuit, individual transmission lines extending from said antennas toward said amplifier, said lines differing from each other by an odd multiple of one-quarter the length of the operating wave, and means for coupling one of said circuits of said amplifier to said transmission lines in like polarity, and the other circuit to said transmission lines in unlike polarity.

5. A radio relaying system for receiving signal energy from one direction and for transmitting amplified signal energy in a different direction, comprising a pair of bidirectional V antennas diverging in the same direction and spaced apart

from each other in the desired direction of maximum radiation by an odd multiple of one-quarter of the length of the working wave, an amplifier having an input circuit and an output circuit, individual two conductor transmission lines extendng from said antennas toward said amplifier, said lines differing from each other by an odd multiple of one-quarter the length of the operating wave, and means for coupling one of said circuits of said amplifier to said transmission lines in like polarity, and the other circuit to said transmission lines in unlike polarity.

6. A system in accordance with claim 3, characterized in this that said means comprises three coils, two of which are coupled in reverse sense with respect to each other and coupled to the third coil, connections from points intermediate the ends of said two coils to said input circuit, connections from the terminals of said third coil to said output circuit, and connections from the conductors of one transmission line to correspondingly located terminals of said two coils, and connections from the conductors of the other transmission line to the other terminals of said two coils.

7. In an antenna system having a pair of antennas and an amplifier coupled between said antennas, the method of operation which includes receiving signals from one direction on both of said antennas, and impressing said signals in like phase upon the input of said amplifier, and applying output energy from said amplifier upon both said antennas in such phase as to produce predominant radiation in a direction substantially opposite to that of the received signals.

8. In an antenna system having a pair of antennas spaced from each other and both coupled to electron discharge device apparatus, the method of operation which includes applying the signal waves received on both said antennas from one direction to said electron discharge device apparatus in substantially the same phase, and applying the signal waves received on both said antennas from another direction to said apparatus in substantially opposite phase.

9. In an antenna system having a pair of antennas spaced from each other and both coupled to electron discharge device apparatus, the method of operation which includes applying the signal waves received on both said antennas from one direction to said electron discharge device apparatus in substantially the same phase, applying the signal waves received on both said antennas from another direction to said apparatus in substantially opposite phase, and radiating energy from both said antennas predominantly toward said other direction.

10. In an antenna system having a pair of antennas spaced from each other and both coupled to an amplifier, the method of operation which includes applying the signal waves received on both said antennas from one direction to said amplifier in substantially the same phase, limiting the amplitude of the signal waves passing through said amplifier, and applying the amplified signal waves to said antennas in such manner as to produce radiation therefrom predominantly in a direction away from that of the received waves.

11. A radio relaying station having a pair of antennas spaced apart from one another, an amplifier, feeder lines from said antennas extending to said amplifier, a circuit intermediate said feeder lines and said amplifier for coupling the input and output of said amplifier to said pair of antennas, said antennas being so spaced and said feeder lines having such lengths and being so connected to said intermediate circuit that signals received on both of said antennas from one direction are applied to the input of said amplifier in like phase and signals received on both of said antennas from an opposite direction are applied to the input of said amplifier in substantially opposite phase.

12. A radio relaying station having a pair of antennas spaced apart from one another, an amplifier, feeder lines from said antennas extending to said amplifier, a circuit intermediate said feeder lines and said amplifier for coupling the input and output of said amplifier to said pair of antennas, said antennas being so spaced and said feeder lines having such lengths and being so connected to said intermediate circuit that signals received on both of said antennas from one direction are applied to the input of said amplifier in like phase and signals received on both of said antennas from an opposite direction are applied to the input of said amplifier in substantially opposite phase, said intermediate circuit comprising three coils, two of which are arranged in reverse sense to each other and coupled to the third coil, said two coils being connected to said feeder lines and the input of said amplifier while said third coil is connected to the output of said amplifier.

13. A radio relaying station comprising a pair of parallel antennas spaced apart from one another by substantially an odd multiple of one-quarter the length of the operating wave, each of said antennas having two arms, an amplifier, a two-conductor feeder connecting the adjacent ends of the arms of each antenna to said amplifier, said feeders differing in length from each other by substantially an odd multiple of one-quarter the length of the operating wave, and circuit means intermediate the input and output of said amplifier and said feeders, said circuit means comprising three coils, two of which are arranged in reverse sense with respect to each other and coupled to the third coil located intermediate said first two coils, connections from points intermediate the ends of said first two coils to the input of said amplifier, connections from the ends of said first two coils to said feeders, and connections from the ends of said third coil to the output of said amplifier, whereby signals received on said antennas from one direction are applied in like phase to the input of said amplifier, while signals received on said antennas from a substantially opposite direction are applied in opposite phase to the input of said amplifier.

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