ANTENNA SIDE LOBE SUPPRESSION SYSTEM
Dale M. Jahn, Garden City, N.Y., assignor to Sperry Rand Corporation, Great Neck, N.Y., a corporation of Delaware
Filed Mar. 23, 1960, Ser. No. 16,983
5 Claims. (Cl. 343-100)

This invention relates to receiving systems associated with electromagnetic wave directional antennas and, more particularly, to means for suppressing undesirable signals received in the side lobes of the directional antenna pattern.

In radar systems and quite often in commercial communications systems, electromagnetic energy is radiated and received by antennas which have highly directional patterns. These directional antenna patterns are characterized by a main beam in which most of the energy is radiated and received. The antenna patterns also include several minor lobes located on either side of the main beam and oriented at different angles to the main beam. In a receiving directional antenna system, electromagnetic energy not received in the main beam may be received in a side lobe. This may result when the receiving antenna is located in a congested area, or may result from intentional efforts to interfere with the reception of signals in the main beam. The reception of signals in the side lobes of a radar system gives rise to the presentation of false targets, or jamming, and in a communications system causes interfering cross-talk in the received signal.

It is an object of this invention to eliminate signals received in the side lobes of a directional antenna pattern whenever corresponding signals are not also received in the main beam of the antenna pattern.

Another object of this invention is to blank the indication of undesirable signals received in the side lobes but not in the main beam of a directional antenna pattern.

A further object of this invention is to derive signals corresponding to electromagnetic waves received in the main beam of a directional antenna and to eliminate signals corresponding to electromagnetic waves received in the antenna pattern but not simultaneously received in the main beam of the antenna pattern.

Still another object of this invention is to indicate the reception of energy in the main beam of such a directive antenna system at power levels below those heretofore usable with this type of device.

These and other objects and advantages of the invention, which will become more apparent from the specifications and claims below, are accomplished in a receiving system having a directional antenna by also providing an omnidirectional receiving antenna and associated receiver means at the receiving location. The signal gain of the antenna-receiver combination of the omnidirectional antenna is made substantially equal to the principal side lobe signal gain of the antenna-receiver combination of the directional antenna. Because of this, the magnitude of a received signal received from the principal side lobe but not in the main beam of the directional antenna will be substantially equal to the magnitude of the corresponding received signal simultaneously received from the omnidirectional antenna. A signal received in the main beam of the antenna, however, will be greater in magnitude than the corresponding signal simultaneously received in the omnidirectional antenna since the main beam directional antenna gain is considerably greater than the side lobe directional antenna gain. Signals corresponding to electromagnetic waves received by each antenna are respectively coupled to two input terminals of a gating means. A third signal is produced proportional to the difference in the magnitudes of the respective signals from the directional antenna and omnidirectional antenna (when the directional signal is greater than the omnidirectional signal) and also is coupled to said gating means.

The signal from the omnidirectional antenna comprises a blanking signal when passed through the gate, and the signal from the directional antenna comprises an enabling signal to enable said gate when only said blanking and enabling signals occur simultaneously. The above-mentioned difference signal comprises an inhibiting signal which inhibits the gate and blocks the blanking signal whenever the inhibit signal is present. The output of the gate is coupled to an indicator and operates to block the presentation of I.F. signals from the directional antenna when no signal is received in the main beam of the directional antenna, that is, when a difference, or inhibit, signal is not produced. However, when such an inhibit signal is produced, the gate is disabled and prevents the formation of a blanking signal, thus allowing the indicator to display the presence of a signal received in the main beam of the directional antenna.

The present invention will be explained in connection with the accompanying drawings, wherein:

FIG. 1 is a block diagram of the side lobe blanking system of the present invention; and

FIG. 2 is an illustration of the antenna patterns which are characteristic of the directional and omnidirectional antennas employed in the present invention.

Referring now in more detail to the drawings, a directional antenna 10 is coupled to receiver 11 which produces video signals in response to R.F. signals received by directional antenna 10. For the sake of an example in this discussion it will be assumed that received signals will be in the form of pulses of electromagnetic energy, such as radar echo pulses reflected from a remotely located object.

Directional antenna 10 has a radiation pattern as illustrated in FIG. 2, comprised of a main beam and a plurality of side lobes which decrease in magnitude as a function of their angular separation from the main beam.

The system illustrated in FIG. 1 also includes an omnidirectional antenna 12 and an associated receiver 13. Omnidirectional antenna 12 has a pattern as illustrated in FIG. 2. The signal gain of the omnidirectional antenna 12-receiver 13 combination is chosen to be substantially equal to the principal side lobe "p" signal gain of the directional antenna 10-receiver 11 combination. As a result of this, an R.F. signal received only in the principal side lobe "p" of the directional antenna 10 and by the omnidirectional antenna 12, but not in the main beam of directional antenna 10, will result in substantially equal video signals being produced at the outputs of the respective receivers 11 and 13. A signal received in the main beam of the directional antenna 10 and by omnidirectional antenna 12, however, will result in a video signal from receiver 11 being greater in magnitude than the corresponding video signal from receiver 13.

The video signals from receivers 11 and 13 are coupled over respective leads 14 and 15 to respective pulse amplifiers 16 and 17. From pulse amplifiers 16 and 17 the respective signals are coupled to threshold circuits 18 and 19. These circuits are substantially identical and operate to pass signals which exceed a predetermined magnitude, this magnitude being chosen to exceed the noise level of the signals, therefore to separate the signals from the noise. The respective signals which exceed the threshold level then are coupled to pulse shapers 20, 21, and then to gate 22.

The video signals from receivers 11 and 13 also are coupled to a difference amplifier 23 which produces an output signal whose amplitude is a function of the difference in magnitude between the two signals simultaneously applied to its input terminals. This difference signal then is coupled to threshold circuit 24 which is similar to the
previously described threshold circuits 18, 19 and operates to separate the difference signal from the noise. Threshold circuit 24 also performs the selective function of passing a difference signal when, and only when, the magnitude of the directional antenna video signal exceeds by a predetermined amount the magnitude of the omnidirectional antenna video signal. The output of threshold circuit 24 is passed through pulse shaper 25 to an input terminal of gate 22.

Gate 22 may be a logical AND circuit which produces an output signal when and only when every input is in a preset state. In this instance, the prescribed states for the respective input signals are as follows: a signal from omnidirectional antenna 13, a signal from directional antenna 10 and no difference signal from threshold circuit 24. When these conditions are present a signal will be passed through gate 22 to a second gate 26. These prescribed conditions arise only when signals are received in the omnidirectional antenna 12 and in side lobes but not the main beam of directional antenna 10.

For convenience in the following discussion, a received omnidirectional antenna video signal from directional antenna 10 coupled into gate 22 will be called a blanking signal, a received signal from directional antenna 10 coupled into gate 22 will be called an enabling signal, and a difference signal coupled from difference amplifier 23 and threshold circuit 24 into gate 22 will be called an inhibiting signal.

The omnidirectional antenna video signal from receiver 11 is also coupled over lead 27 into gate 26, and is passed through said gate to indicate 28 to present an indication of detected targets only when a blanking signal from gate 22 is not simultaneously present.

In discussing the operation of the blanking system of this invention it must be kept in mind that there is no way in which the system can determine the exact location of the target. The entire operation is based on the fact that it is impossible to receive a signal directly from a moving target, while the instrument is in a position in which it is being observed. In other words, it is impossible to receive a signal from a target which is in the path of an omnidirectional antenna receiver, while the instrument is in a position in which it is being observed.

The video signals from directional antenna receivers 11 and omnidirectional antenna receiver 13 are coupled to difference amplifier 23 and because the signal gain of the main beam directional antenna receiver combined with the signal gain of the omnidirectional antenna receiver is greater than the signal gain of the omnidirectional antenna receiver alone, the video signal will be greater in magnitude than the corresponding simultaneous occurrence of omnidirectional antenna video signals, thus resulting in an output signal from difference amplifier 23, this difference signal is coupled through threshold circuit 24 where it is separated from the noise, is coupled through pulse shaper 21 and then to gate 22 as an inhibit signal. This inhibit signal causes gate 22 to be blocked in a condition to prevent the passage of a blanking signal from the omnidirectional antenna 12. Therefore, because there is no blanking signal passed by gate 22 to the input to gate 26, the directional antenna video signals coupled from receiver 11 over lead 27 to gate 26 will be passed by gate 26 to indicator 28 which will present an indication of the target in the main beam of the directional antenna pattern.

In contrast to the above-described mode of operation, consider next the operation of the system when a signal is received in the principal side lobe but not in the main beam of the directional antenna pattern, as at "B" in FIG. 2. A corresponding signal will be simultaneously received by the omnidirectional antenna 12. Received video signals from directional antenna receiver 11 and omnidirectional antenna receiver 13 will be respectively coupled over leads 14 and 15, through pulse amplifiers 16 and 17, threshold circuits 18 and 19, pulse shapers 20 and 21 in the manner previously explained, and corresponding enabling and blanking signals will be coupled to gate 22. In this instance, the magnitude of the directional antenna video signal and the corresponding omnidirectional antenna video signal will be substantially equal as a result of the two antenna-receiver gain characteristics being chosen as explained previously. Therefore, there will be no output signal from threshold circuit 24 and no inhibiting pulse will be coupled to gate 22. Logical AND gate 22 therefore has its three input signals in the prescribed conditions and will pass the blanking pulse to gate 26. This blanking pulse blocks gate 26 and prevents the directional antenna video signals on lead 27 from being coupled to indicator 28. There therefore will be no indication of the signal which is received in the side lobe but not simultaneously received in the main beam of the directional antenna pattern.

Because difference amplifier 23 and threshold circuit 24 will produce an inhibit signal only when the directional antenna video signal is greater in magnitude than the omnidirectional antenna video signal, the system of this invention also will operate as just described to blank the indicator in the event that signals are received in the minor side lobes of the directional antenna but not in the main beam.

From the discussion of the operation of this invention it is apparent that the functioning of gates 22 and 26 in response to their respective input signals provides a non-ambiguous operation of the system to blank the indicator whenever a signal is not received in the main beam of the directional antenna. One of the important features which provides the non-ambiguous operation of the system is the generation of the inhibit signal to block the blanking signal only when the magnitude of the directional antenna signal exceeds the magnitude of the omnidirectional antenna signal. Because of the parameters chosen for the system, this condition can occur only when a signal is received in the main beam of the directional antenna, and thus the indicator can display only these main beam directional antenna signals.

While the invention has been described in its preferred embodiments, it is understood that the words which have been used are words of description and limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention in its broader aspects.
ional antenna, means for coupling said blanking, enabling and inhibiting signals to said controlling means, said controlling means operating in response to said three last named signals coupled thereto to block the passage of received electromagnetic waves received by said directional antenna, said controlling means operating in response to said blanking signals and said enabling signals to pass said blanking signals to said glistening means, said controlling means further including means providing an inhibiting signal when the magnitude of a signal received by said omnidirectional antenna, said controlling means operating in response to said inhibiting signals in conjunction with the magnitude of a corresponding signal simultaneously received by said omnidirectional antenna, said controlling means operating in response to said inhibiting signals to prevent the coupling of simultaneously occurring blanking signals to said glistening means, whereby said indicator means is blanked upon the presence of the principal lobe but not the main beam of said directional antenna and is unblanked to receive signals from the directional antenna upon the presence of a signal in the main beam of said directional antenna.

4. In a directional antenna system means for suppressing side-lobe signals comprising a directional receiving antenna having a directional pattern including a main beam and at least one side lobe, an omnidirectional receiving antenna, receiving means for deriving a signal in response to electromagnetic waves received by said directional antenna, receiving means for deriving a signal in response to electromagnetic waves received by said omnidirectional antenna, the signal gain of said omnidirectional antenna and receiver combination being substantially equal to that of said directional antenna, and said directional receiving means for providing an indication of signals coupled thereto, separate means for coupling signals received from said directional antenna to said indicator means for indication thereon, threshold means coupled to said omnidirectional antenna receiving means for providing blanking signals whenever the signals from said omnidirectional antenna exceed a predetermined value, coupling means interconnecting said threshold means and said indicating means to block said indicating means when said blanking signals are coupled thereto, control means for controlling the coupling of said blanking signals to said indicator means and inhibiting means for producing enabling signals in response to signals received from said directional antenna to permit said blanking signals to blank said indicator when only said blanking signal and said enabling signals simultaneously are present, said control means further including means for producing enabling signal if both said blanking signal and said enabling signal are present simultaneously, means for producing an inhibiting signal when and only when the magnitude of a received signal from said directional antenna receiver exceeds a predetermined amount the magnitude of a simultaneously received signal from said omnidirectional antenna receiver, means for coupling said inhibiting signal to said glistening means, said glistening means operating in response to the received signal from said directional antenna receiver, a glistening means coupled to receive said blanking signal and said enabling signal and adapted to pass said blanking signal if both said blanking signal and said enabling signal are present simultaneously, means for producing an inhibiting signal when and only when the magnitude of a received signal from said directional antenna receiver exceeds a predetermined amount the magnitude of a simultaneously received signal from said omnidirectional antenna receiver, and said means for coupling blanking signals to said glistening means, said glistening means operating in response to the received signal from said directional antenna receiver, a glistening means coupled to receive said blanking signal when an inhibiting signal is coupled simultaneously thereto, a second glistening means coupled to receive the output of said first glistening means, means for coupling said received signals from said omnidirectional antenna receiver and said second glistening means, said second glistening means being normally operative to pass the received signal from said directional antenna but being blocked to prevent passage of said received signals when a signal from said first glistening means is coupled thereto, and an indicator means coupled to said second glistening means for providing an indication of signals coupled thereto.

5. In a directional receiving system of the type in which a directional antenna has a primary radiation pattern in space and an omnidirectional antenna has an auxiliary radiation pattern in space, said primary radiation pattern being greater than said auxiliary radiation pattern in a desired directional region, said system further having individual receivers connected to each antenna, and a comparison circuit wherein the outputs of the two receivers are combined so as to produce an output signal when and only when a signal received in the directional antenna exceeds by a given amount the magnitude of a signal received simultaneously in the omnidirectional antenna, the improvement comprising means for producing a blanking signal when and only when the magnitude of a received signal from said omnidirectional antenna exceeds a predetermined value, means for producing an enabling signal when and only when the magnitude of the received signal from the directional antenna receiver exceeds a predetermined value, a first glistening means coupled to receive said blanking signal and said enabling signal, means for coupling said enabling signal to said glistening means if both said blanking signal and said enabling signal appear simultaneously, a pulse shaper coupled to the out-
put of said comparison circuit and adapted to form an inhibiting pulse in response to the output signal of said comparison circuit, means for coupling said inhibiting signal to said first gating means, said first gating means operating to block the passage of said blanking signals when an inhibiting signal is coupled simultaneously thereto, a second gating means coupled to receive the output of said first gating means, separate means for coupling signals directly from said directional antenna receiver to said second gating means, said second gating means being normally operative to pass all signals from said directional antenna receiver, but being blocked to prevent the passage of said received signals when a blanking signal from said first gating means is coupled thereto, and an indicator means coupled to said second gating means for providing indications of directional antenna receiver signals coupled therethrough.

References Cited in the file of this patent

UNITED STATES PATENTS

2,825,900 Colbohm 3,094,695 Colbohm 4, 1958