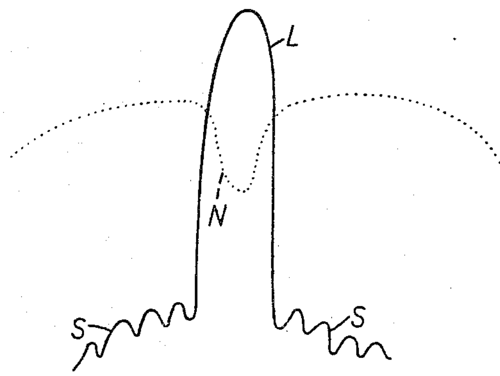

FIG. 1.

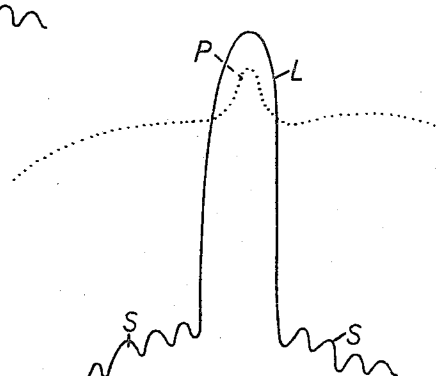

FIG. 2.

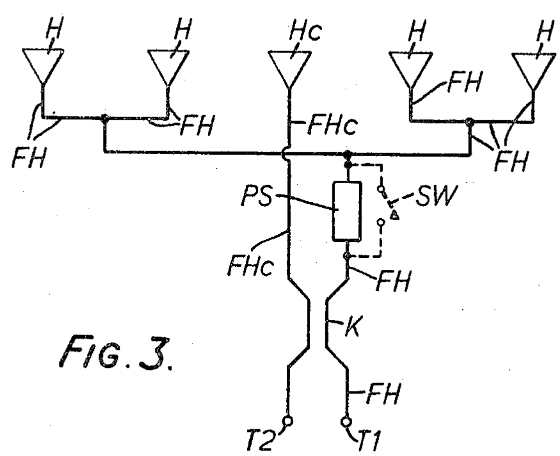

FIG. 3.

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FIG. 4

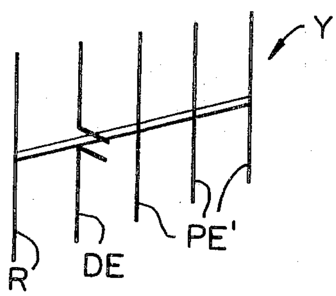


FIG. 5

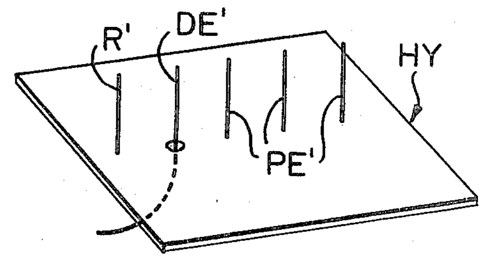
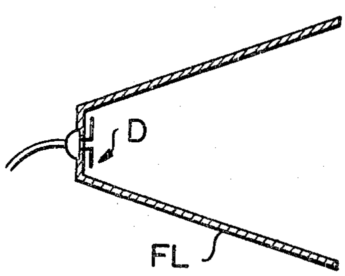


FIG. 6



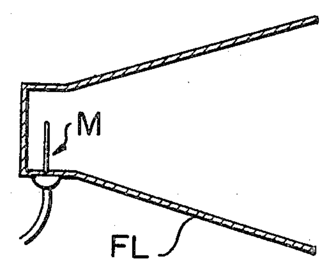


FIG. 7

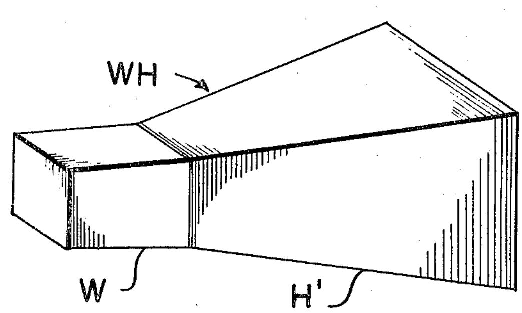


FIG. 8

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3,325,816

SIDELOBE SUPPRESSING ANTENNA SYSTEM COMPRISING DIRECTIONAL COUPLER AND PHASE CONTROL MEANS FOR BEAM SHAPING

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Claims priority, application Great Britain, July 29, 1963, 29,903/63
10 Claims. (Cl. 343—777)

This invention relates to aerial systems and has for its object to provide improved efficient aerial systems adapted to produce two radiation diagrams or patterns, one having a sharp narrow beam-like lobe and the other being relatively broad and much less directional. Aerials with diagrams of this nature are required for certain so-called side lobe suppression radar systems. In these particular side lobe suppression systems a number of pulses is transmitted—in one such system three pulses are transmitted—with different sharpness of directivity, differentiation between the pulses at the automatically responding receiver being obtained due to the fact that the different pulses are transmitted in accordance with different radiation diagrams one being a narrow radiation diagram and another, the transmission on which is of lower field strength, being a wider radiation diagram. In some such systems the wider radiation diagram has a notch or dip in the direction of the narrow diagram. The co-operating receiver compares the strength at which the different pulses are received—it is only over the narrow "beam" that the strength of the sharply directional pulse exceeds that of the other pulse—and is so arranged as to be effectively responsive only to the sharply directional pulse.

In the drawings:

FIGURE 1 is a representation of two radiation diagrams and shows in full lines a diagram having a directional lobe and in broken lines a less directional diagram of lower field strength having a point of lowest field strength portrayed therein.

FIGURE 2 is a representation of two radiation diagrams and shows in full lines a diagram having a directional lobe and in broken lines a less directional diagram of lower field strength and having a point of highest field strength portrayed therein.

FIGURE 3 is a schematic representation of one embodiment of the present invention and shows an aerial array fed by two separate feeders coupled by a directional coupler and having phase shift means inserted in one of the two feeders.

FIGURE 4 is a perspective representation of an aerial suitable for use in the present invention and shows a common Yagi aerial.

FIGURE 5 is a perspective representation of an aerial suitable for use in the present invention and shows a common half Yagi aerial.

FIGURE 6 is a vertical sectional view of an aerial suitable for use in the present invention and shows a monopole antenna and an associated conducting flare.

FIGURE 7 is a vertical sectional view of an antenna suitable for use in the present invention and shows a dipole antenna associated with a conducting flare.

FIGURE 8 is a perspective representation of an aerial suitable for use in the present invention and shows a waveguide horn having a waveguide portion and an associated outwardly opening horn.

FIGURE 1 of the accompanying drawings typifies the two diagrams required. The diagram shown in full line is a diagram comprising a sharply directional lobe L of high field strength with side lobes S of much lower field strength. The other diagram—shown dotted—is much less directional, has a field strength well below that of the lobe L and has a dip or notch N substantially in the position of the main lobe L. If space is explored by an aerial system with radiation diagrams as shown in FIGURE 1, a target encountered by the system will receive pulses from the sharply directional transmission more strongly than from the less directional transmission only when it lies in the narrow main beam of the sharply directional radiation diagram. By arranging the receiver to reject any group of pulses in which the pulse strength from the less directional transmission exceeds that received from the sharply directional transmission, the sidelobes of the sharply directional transmission may be rejected, i.e. made ineffective at the receiver. It is thus possible to provide sufficient receiver sensitivity or transmitter power for long range working without getting false responses due to sidelobes at short range.

Sidelobe suppression radar systems in general (and not only those operating as above described) are mainly employed for secondary radar systems, such as IFF (Identification, Friend or Foe) systems or in air traffic control systems, though these are not the only applications. In such systems a responder carried by an aircraft if arranged to respond in a required predetermined manner only if a correct pre-determined succession of pulses of required pre-determined relative strengths is received. The present invention is not of itself concerned with providing sidelobe suppression radar systems but only with aerial systems having radiation diagrams suitable for use therein.

However, there are sidelobe suppression radar systems—including a two pulse system—which requires radiation diagrams as represented in FIG. 2 of the accompanying drawings rather than as represented in FIG. 1. In FIG. 2 there is a diagram, shown in full line, with a sharply directional lobe L of high field strength with side lobes S of much lower field strength. This diagram is as in FIG. 1. The other diagram—shown dotted—is much less directional than the full line diagram, and has a field strength well below that of the lobe L outside said lobe and substantially equal to or below it (the latter is shown in the figure) inside said lobe. It differs, however, from the dotted line diagram of FIG. 1 in that there is no dip or notch N but instead there is a directional lobe P in the direction of the lobe L. The lobe P may be wholly inside the lobe L as shown by FIG. 2, through, in some cases the "skirts" i.e. the sides of the lobe P may lie a little outside the skirts of the lobe L. The present invention seeks to provide improved aerial systems giving radiation diagrams as typified by FIG. 2.

Although the present invention does not itself provide sidelobe suppression radar systems but only aerial systems having radiation diagrams suitable for certain sidelobe suppression radar systems, such aerial systems will, for convenience, be termed "sidelobe suppressing aerial systems."

According to this invention a sidelobe suppressing aerial system comprises a plurality of aerial elements constituting an array, a feeder leading to a portion of said array, said portion comprising at least one of said elements, a second feeder leading to the other elements of the array and a directional coupler having two input terminals and two output terminals and coupling the two feeders, the whole arrangement being such that when input is applied to that feeder which causes more power to be supplied from one output terminal of the coupler to said portion than is supplied from the other output terminal of the coupler to said other elements of the array all the elements of the array are fed substantially in phase while when input is applied to the other feeder the said portion is fed substantially in phase opposition to the said other elements of the array.

The directional coupler employed in this invention may be any of a number of known couplers which provide an inherent 90° phase shift between coupler outputs upon energization of a single input terminal. Thus, upon application of an input signal to one side of the coupler, the output from the non-energized side of the coupler will lag the output from the energized side by 90°. Such 90° phase shift in the directional coupler must be taken into consideration in order to provide a 180° phase difference between the input to the aforementioned portion of the array and the input to the remaining elements of the array. To provide the desired 180° phase difference at the inputs to the array the actual physical lengths of the feeders may be suitably chosen with this phase relationship in mind. The physical lengths of the feeders from the output terminals of the coupler to the input terminals of the array may be dimensioned to provide the desired 180° phase difference upon energization of one coupler input. (For example, one of the feeders may be made to differ in length from the output of the directional coupler to the array input by $\frac{1}{4}\lambda$ in comparison to the length of the remaining feeder from its associated coupler output to the input of the array.) Alternatively, the physical length of the feeders may be arranged to provide zero phase difference between the inputs to the array, upon energization of one coupler input terminal. (As for example, by the reduction in length of one feeder by $\frac{1}{4}\lambda$ to provide for the 90° lag in that feeder). In such an arrangement the desired 180° phase shift may conveniently be provided by the insertion of a 180° phase shifter between one output terminal of the directional coupler and the associated input to the array. This latter arrangement may provide a further advantage in that a means for short-circuiting the 180° phase shifter may be utilized, thus providing a system capable of producing, at will, array radiation corresponding to any of the four diagrams of FIGURES 1 and 2.

The aerial elements may take any of a variety of different forms, e.g., they may be commonly known as Yagi aerials, generally indicated by the reference Y in FIGURE 4, having a driven element DE, a reflector R and parasitic element PE mounted on a support element SU; they may be well known arrays of monopoles over the ground (i.e., so-called "half Yagi aerials"), generally indicated by the reference letters HY in FIGURE 5, having a ground plate GP, a driven element DE′, a reflector R′ and a number of parasitic elements PE′; they may be monopole aerials as shown in FIGURE 6 having a conducting flare FL; they may be dipole aerials D as shown in FIGURE 7, again with a conductive flare FL′; or they may be waveguide horns generally referred to by the reference WH as shown in FIGURE 8 having a waveguide portion W associated with an outwardly opening horn H′.

Preferably the portion of the array to which one feeder leads is a central portion. In the simplest case it consists of only one aerial element.

Normally the spacing of the elements will be a little below one wavelength though this is by no means critical and satisfactory results are obtainable with smaller or greater spacings if the aerial elements are suitably chosen and designed, e.g. with colinear spacings between 0.5λ and 1.5λ where λ is the wavelength.

FIG. 3 of the accompanying drawings shows schematically one embodiment of the invention using radio horns fed over lengths of microwave strip line represented, for simplicity of drawing, by more single straight lines.

Referring to FIG. 3 this shows an array of radio horns H with the central portion of the array—as shown consisting of one horn—distinguished by the suffix reference C. The said central portion is fed through the feeder FH_C. The rest of the array is fed through the branched feeder FH. The two feeders are coupled by a directional coupler K inserted in their runs and a 180° phase shifter PS is inserted between one output terminal of the coupler and the portion of feeder FH leading to the horns H. Across this phase shifter there may be provided means for removing the 180° shift produced thereby. These means are diagrammatically represented by a switch SW which is shown in broken lines to indicate that its provision is optional.

Input may be applied to either of the two feeders at feeder terminals T1 or T2 (represented merely by dots). When the highly directional transmission is required (full line curve of FIG. 2) and assuming the switch SW to be open, input is applied at T1. Maximum power from one coupler output terminal is fed over feeder FH and the phase shifter PS to the horns H and a small proportion is fed from the other coupler output terminal through feeder FH_C to horn H_C. If the switch SW is open the output to horn H_C will be in phase opposition to the outputs to horns H, resulting in a small but negligible degradation in the radiation pattern S as compared to that obtained when the horns H_c and H are fed in phase. When input is applied at T2 the majority of the power passes to the central element H_C and a small proportion passes through the coupler and the phase shifter PS to the horns H. Because of the phase shifter PS all the horns are fed substantially in phase and a radiation diagram like the dotted line diagram of FIG. 2 is obtained. In arrangements, like that illustrated in FIG. 3, adapted to provide either of the diagrams of FIGS. 1 and 2 at will, provision may be made to ensure that when input is applied at T1 the switch SW is closed so that the aforementioned small degradation of radiation diagram is avoided.

When the switch SW is closed the arrangement of FIG. 3 operates to produce radiation diagrams as represented in FIG. 1.

I claim:

1. A sidelobe suppressing aerial system comprising a plurality of aerial elements constituting an array, a first feeder leading to a portion of said array, said portion comprising at least one of said elements, a second feeder leading to the other elements of the array, directional coupler means having first and second input terminals and first and second output terminals and coupling the two feeders, said coupler providing more power to said first feeder than to said second feeder when an input is fed to said first input terminal, means for providing an in-phase relationship between the input to all of said aerial elements of the array when an input is fed to said first input terminal, and for providing a phase opposition relationship between the input to said portion and the input to said other elements in the array when an input is fed to said second input terminal.

2. An aerial system as claimed in claim 1 wherein the electrical length from one of said input terminals to said portion of the array differs by 180° of phase from the electrical length from the other of said input terminals to said other elements of the array, said feeders having a physical length adapted to provide 0° phase difference between the input to said portion of said array and the input to the other elements of the array and said system further including phase shift means between one of said output terminals and the element or elements of the array fed therefrom for producing said 180° difference in phase between the input to said portion of said array and the input to the other elements of the array.

3. An aerial system as claimed in claim 2 wherein there is provided means for short-circuiting said phase shift means at will.

4. An aerial system as claimed in claim 1 wherein the aerial elements are Yagi aerials.

5. An aerial system as claimed in claim 1 wherein the aerial elements are half Yagi aerials.

6. An aerial system as claimed in claim 1 wherein the aerial elements are monopole or dipole aerials enclosed in conducting flares.

7. An aerial system as claimed in claim **1** wherein the aerial elements are waveguide horns.

8. An aerial system as claimed in claim **1** wherein the portion of the array to which one feeder leads is a central portion.

9. An aerial system as claimed in claim **1** wherein the portion to which one feeder leads consists of only one aerial element.

10. An aerial system as claimed in claim **1** wherein the spacing of the aerial elements is between 0.5λ and 1.5λ where λ is the wavelength.

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