

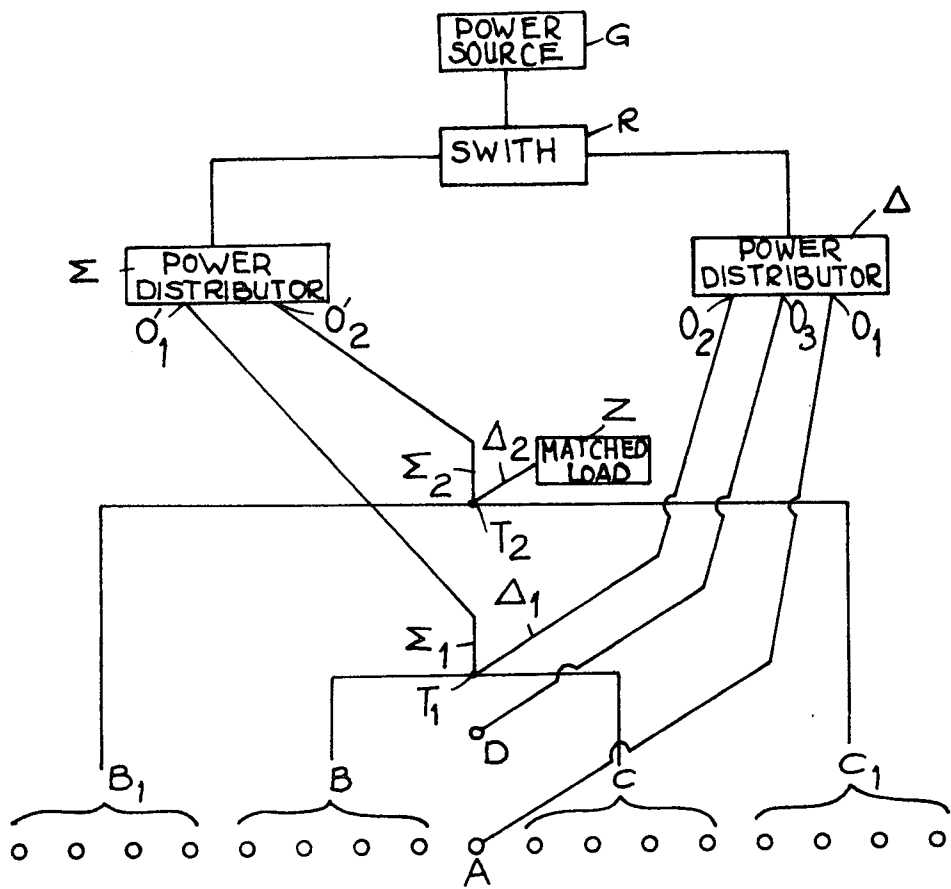
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[73] Assignee **Thomson-CSF**
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[33] **France**
[31] **139 374**

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[54] **SUM AND DIFFERENCE ANTENNA**
3 Claims, 5 Drawing Figs.

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343/816
[51] Int. Cl. H01g 3/26,
H01g 21/00
[50] Field of Search 343/853-
—4, 837, 777—8, 816

ABSTRACT: The radiation elements of an antenna comprising a linear array of elements and a further compensation element are fed so that the radiation pattern of a central portion of the linear array is in quadrature of phase with the radiation pattern of the remaining elements of the array, for the formation of a nondirective pattern covering the secondary lobes of the directive pattern obtained through an in-phase feeding of the elements of the linear array.



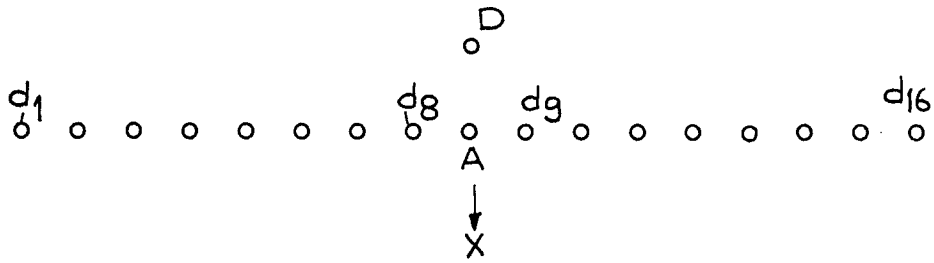


Fig.1

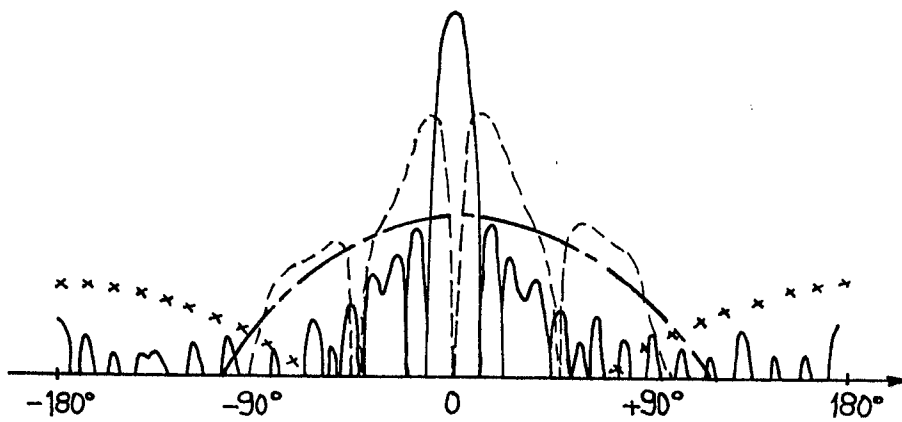


Fig.2

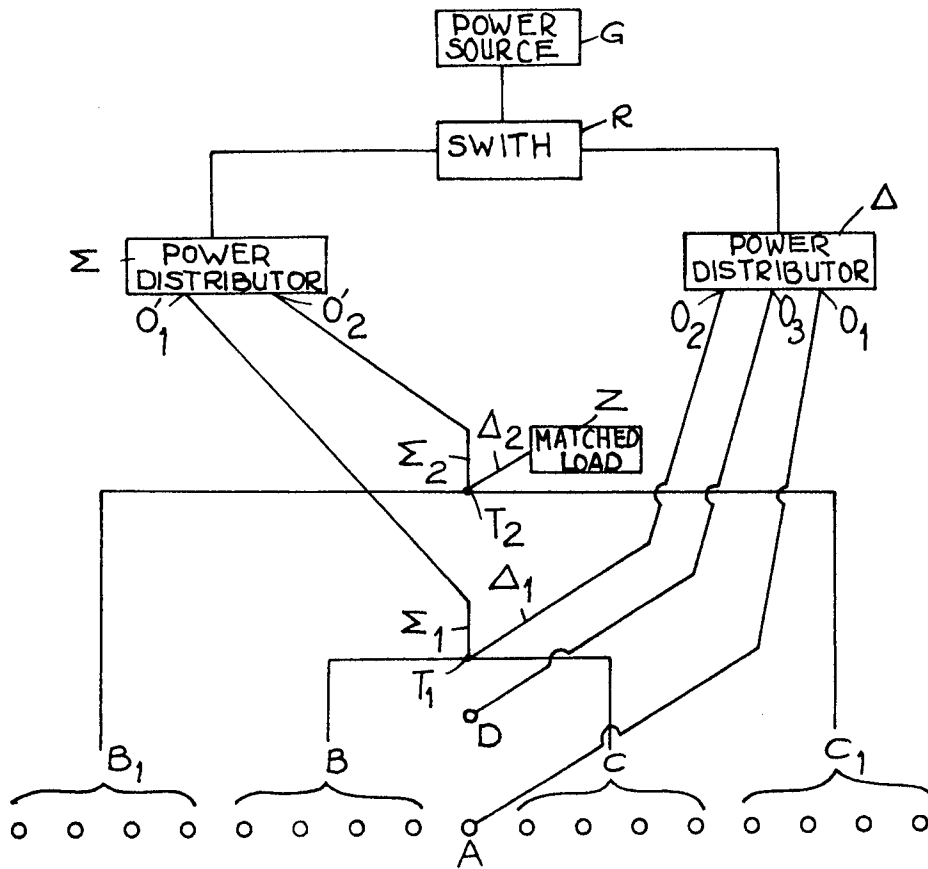


Fig. 3

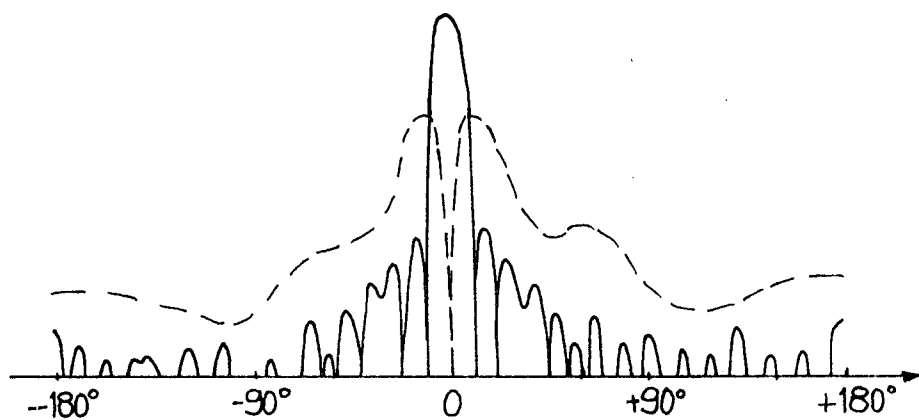


Fig. 4

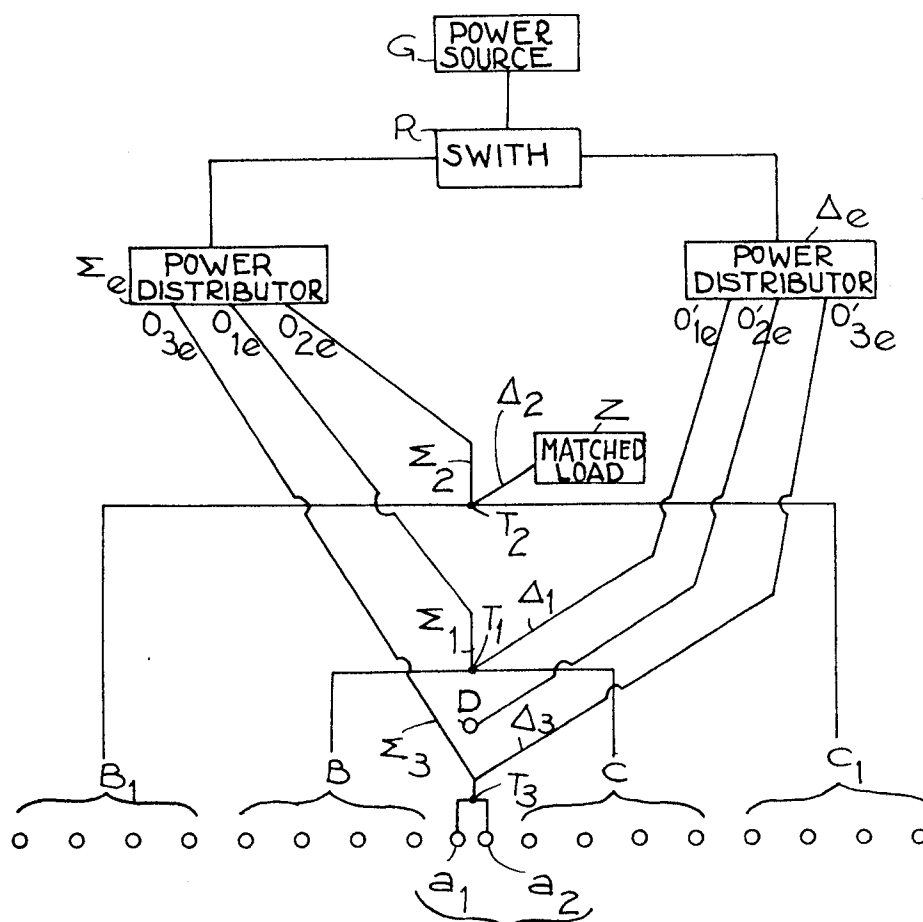


Fig. 5

SUM AND DIFFERENCE ANTENNA

The present invention relates to antennae of the kind comprising an array of radiating elements, such as for example dipoles, and means for feeding said array in two different ways in order to obtain either a pencil beam radiation pattern, also referred to as a sum pattern, of the kind generally produced by in-phase feeding of all the elements, or a wide radiation pattern covering the secondary lobes of the pencil beam pattern, this wide pattern also being referred to as a difference pattern because of the way in which the individual elements are generally fed to produce it. Such antennae are used in particular in electromagnetic identification systems of the kind known as IFF (identification friend or foe) systems or "secondary" radar systems.

A combination of the two radiation patterns is designed essentially to eliminate from the signals picked up by means of the sum pattern, those due to the secondary lobes and it is therefore important that the difference pattern should cover all these lobes. With conventional antennae, this is not entirely the case.

It is an object of the invention to avoid this drawback.

According to the invention there is provided an antenna system alternately having a directive radiation pattern and a nondirective radiation pattern, said system comprising a linear array of radiating elements located symmetrically with respect to a symmetry plane, an a further element in said plane; said array comprising a central group of K elements, including two symmetrical subgroups of $K/2$ elements if K is even and two symmetrical subgroups of $K-1/2$ elements if K is odd, and two symmetrical groups of p elements on both sides of said central group, K and p being integers, said system further comprising feeding means for alternately (i) for forming said directive radiation pattern, feeding in phase at least the $2p$ elements of said two symmetrical groups and (ii) for forming said nondirective radiation pattern, simultaneously: feeding in phase, a first group of n consecutive elements, located on one side of the central group of elements, n being an integer smaller than $p+1$ said first group of n elements, designated in the following as "lateral" group for the sake of brevity, being a part of one of said groups of p elements; feeding in phase, but in phase opposition to said first lateral group, a second lateral group of n elements symmetrical with said first lateral group with respect to said central group; feeding, in phase quadrature with respect to said lateral groups, said further element; and feeding said central group in phase with either one of said lateral groups if K is odd, and the elements of said two symmetrical subgroups in phase opposition relatively to each other and in phase quadrature with respect to the elements of the lateral groups if K is even, thereby obtaining a radiation pattern in quadrature of phase with that resulting from the feeding in phase opposition of said two lateral groups.

For a better understanding of the invention and to show how the same may be carried into effect, reference will be made to the drawings accompanying the following and in which:

FIG. 1 schematically illustrates a plan view of the element array of an antenna in accordance with the invention;

FIG. 2 shows the way in which the various groups of radiators contribute to the difference radiation pattern;

FIG. 3 schematically illustrates an example of an antenna assembly, including the radiator elements and their energizing means;

FIG. 4 illustrates the sum and difference radiation patterns produced by the antenna of FIG. 3; and

FIG. 5 schematically illustrates another example of an antenna assembly.

By way of example, it will be assumed that the sum pattern produced by the antenna is narrow in the azimuth plane and wide in elevation. The radiators of the antenna in accordance with the invention form a regular array, for example an horizontal array of vertical dipoles, which form two groups of

p elements ($p=8$ in the figure), $d_1, d_2, \dots, d_8$, and $d_9, \dots, d_{16}$, regularly spaced on either side of a central group of K elements; in the figure K has been assumed to be equal to 1 the central group being in the present instance built up by dipole A only.

A radiator D is located at the rear, in a known manner.

The sum pattern, or interrogation pattern in the case of an IFF system, is produced by feeding in phase all the radiators of the array, possibly, if K is odd and for technological reasons, with the exception of the elements of the central group. This radiation pattern is shown in full line in FIG. 2.

The difference pattern, or "check" pattern in the aforementioned case, is formed by the sum of several elementary patterns:

the pattern produced by feeding in phase opposition the radiator groups B and C, that is to say the lateral groups of radiators, respectively comprising a number of n of successive radiators, this number being preferably less than p ;

the pattern produced by feeding the radiator D in phase quadrature with respect to the elements of groups B and C;

a pattern produced by feeding in phase with one of the group B and C the central group if K is odd or by feeding the two symmetrical parts of the central group in phase quadrature with the groups B and C and in phase opposition with respect to each other if K is even.

The supplies of the radiators, resulting in the formation of two patterns, respectively directive and broad, can be effected, with K odd, in accordance with the diagram of FIG. 3 where A constitutes the central group, K being taken equal to 1, and where p is taken equal to eight, the lateral groups B and C of each $n=4$ elements being parts of the two symmetrical groups of each $p=8$ elements, built up respectively by the assemblies B, B₁ and C, C₁: a power source G feeds a switch R which feeds in turn power-splitters Σ and Δ , the former having two in-phase outputs $0'_1$ and $0'_2$ and the latter two in-phase outputs 0_1 and 0_2 and an output 0_3 in phase quadrature with the preceding ones, which feed as shown in FIG. 3 two hybrid junctions, for example magic-Tees T₁ and T₂ with respective sum channels Σ_1 and Σ_2 and respective difference channel Δ_1 and Δ_2 ; Z represents a matched load, the channel Δ_2 not being used.

In FIG. 4, the two antenna radiation patterns corresponding to the two types of supply have been shown respectively in full line and broken line.

In this example, the central group which comprises only the radiator A is not fed, when the production of the directional radiation pattern is desired, this in order to avoid a loss of supply energy or a complication of the circuit. However, it goes without saying that there is theoretically no reason why this group should not be fed.

The diagram of FIG. 5 is an example of a radiator feeding circuit resulting in the alternate formation of a directive and a broad pattern with K even, the central group then comprising two symmetrical subgroups: the switch R couples the power source G to two power distributors Σ_e and Δ_e alternately the former having three in-phase outputs, $0_{1e}, 0_{2e}, 0_{3e}$ and the latter, two in-phase outputs $0'_{2e}, 0'_{3e}$ and an output $0'_{1e}$ in phase quadrature with the preceding ones. Outputs $0_{1e}, 0_{2e}, 0_{3e}$ are coupled respectively to the respective sum channels $\Sigma_1, \Sigma_2, \Sigma_3$ of three four-arm hybrid junctions T₁, T₂, T₃, whose respective difference channels are respectively coupled to output $0'_{1e}$, to a matched load and to output $0'_{3e}$, the remaining channels of junction T₁ being coupled to the elements of groups B and C respectively, those of groups B₁ and C₁ and those of junction T₃ to the symmetrical subgroups of the central group here reduced respectively to elements a_1 and a_2 . Output $0'_{2e}$ is coupled to element D.

The diagrams of FIGS. 3 and 5 relate to a transmitting antenna; however, the antenna may of course be operated without any structure modification as a receiver antenna, the principle of reciprocity being in force here since all the circuits are passive circuits.

The antenna in accordance with the invention makes it possible to achieve a substantial improvement in the ratio between the signals obtained with the respective two radiation patterns. This means that for a given range, the probability that an associated transponder will respond is higher, or, that for a given probability of response the range is increased; on the other hand, as already pointed out, the effective aperture of the beam, as defined by the intersection between the two radiation patterns, is virtually constant due to the fact that the slopes of the patterns, at their points of intersection, are substantially reverse of each other; the aperture angle is moreover capable of further reduction by reducing the level of the sum pattern in the central zone.

Of course, the invention is in no way limited to the embodiments described and illustrated here purely by way of example.

What I claim is:

1. An antenna system alternately having a directive radiation pattern and a nondirective radiation pattern, said system comprising a linear of radiating elements located symmetrically with respect to a symmetry plane, and a further element in said plane, said further element being located outside said linear array; said array comprising a central group of K elements, including two symmetrical subgroups of $K/2$ elements if K is even and two symmetrical subgroups of $(K-1)/2$ elements if K is odd, and two symmetrical groups of p elements on both sides of said central group, K and p being integers, said system further comprising feeding means for alternately (i), for forming the directive radiation pattern: feeding in phase at least the $2p$ elements of said two symmetrical groups and (ii), for forming said nondirective radiation pattern, simultaneously: feeding in phase a first lateral group of n consecutive elements, located on one side of the central group of elements, n being an integer smaller than $p+1$; feeding in phase, but in phase opposition to said first lateral group, a second lateral group of n elements symmetrical with said first lateral group with respect to said central group; feeding, in phase quadrature with respect to said lateral groups, said further element; and feeding said central group in phase with either one of said lateral groups if K is odd, and the elements of said two symmetrical subgroups in phase opposition relatively to each other and in phase quadrature with respect to the elements of the lateral groups if K is even, thereby obtaining a radiation pattern in quadrature of phase with that resulting from the feeding in phase opposition of said two lateral groups.

2. An antenna system according to claim 1, wherein, said central group comprising an odd number of elements, said feeding means comprise: a power means having an output;

switching means having an input coupled to said power means output, and a first and a second output; a first power distributor having an input coupled to said first output of said switching means and a first and a second in-phase outputs; a second power distributor having an input coupled to said second output of said switching means and a first output coupled to said central group, a second output, and a third output coupled to said further element, the energy at said third output being shifted by $\pi/2$ with respect to that at said first and second outputs of said second distributor; a first hybrid junction having a "Difference" channel coupled to said second output of said second distributor, a "Sum" channel coupled to said first output of said first distributor, and two further channels respectively coupled to said first and second groups of p elements and a second hybrid junction having a Difference channel coupled to a matched load, a Sum channel coupled to said second output of said first distributor, and two further channels respectively coupled to the two groups of consecutive $(p-n)$ elements located symmetrically with respect to the central group and not including the elements of said groups of n channels.

3. An antenna system according to claim 1, wherein, K being even, said feeding means comprise: a power means having an output switching means having an input coupled to said power means output, and a first and a second output; a first power distributor having an input coupled to said first output of said switching means, a first, a second and a third in-phase outputs; a second power distributor having an input coupled to said second output of said switching means, a first output, a second output coupled to said further element and a third output, the energy at said last mentioned first output being in quadrature of phase with respect to that at said last mentioned second and third outputs; a first hybrid junction having a "Difference" channel coupled to said first output of said second distributor, a "Sum" channel coupled to said first output of said first distributor and two further channels respectively coupled to said first and second group of n elements; a second hybrid junction having a difference channel coupled to a matched load; a Sum channel coupled to said second output of said first distributor, and two further channels respectively coupled to the two groups of consecutive $(p-n)$ elements located symmetrically with respect to the central group and not including the elements of said lateral groups of n elements; and a third hybrid junction having a Difference channel coupled to said second output of said third distributor, a Sum channel coupled to said third output of said first distributor and two further channels coupled to the elements of said two subgroups respectively.