

April 11, 1967

G. DUBOST

3,314,069

WIDE BAND DIRECTION FINDER ANTENNA

Filed May 6, 1964

2 Sheets-Sheet 1

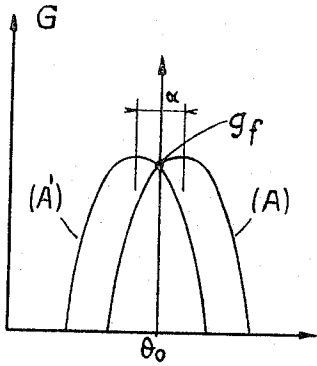


FIG. 2
PRIOR ART

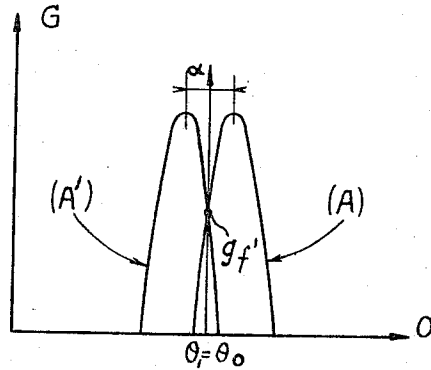


FIG. 3
PRIOR ART

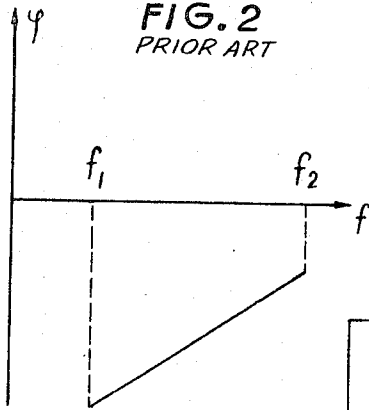


FIG. 4

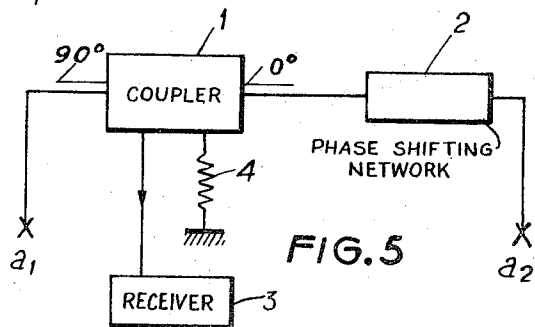


FIG. 5

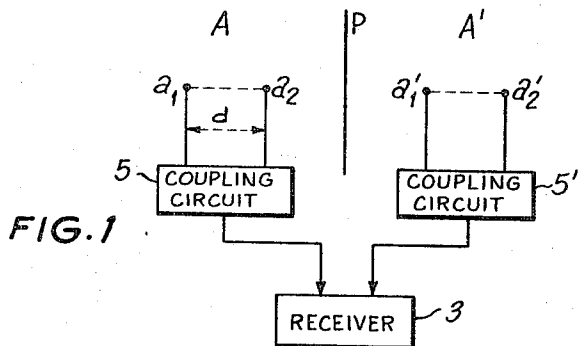


FIG. 1

Inventor
Gérard Dubost
By Cushman, Darby & Cushman
Attorneys

April 11, 1967

G. DUBOST

3,314,069

WIDE BAND DIRECTION FINDER ANTENNA

Filed May 6, 1964

2 Sheets-Sheet 2

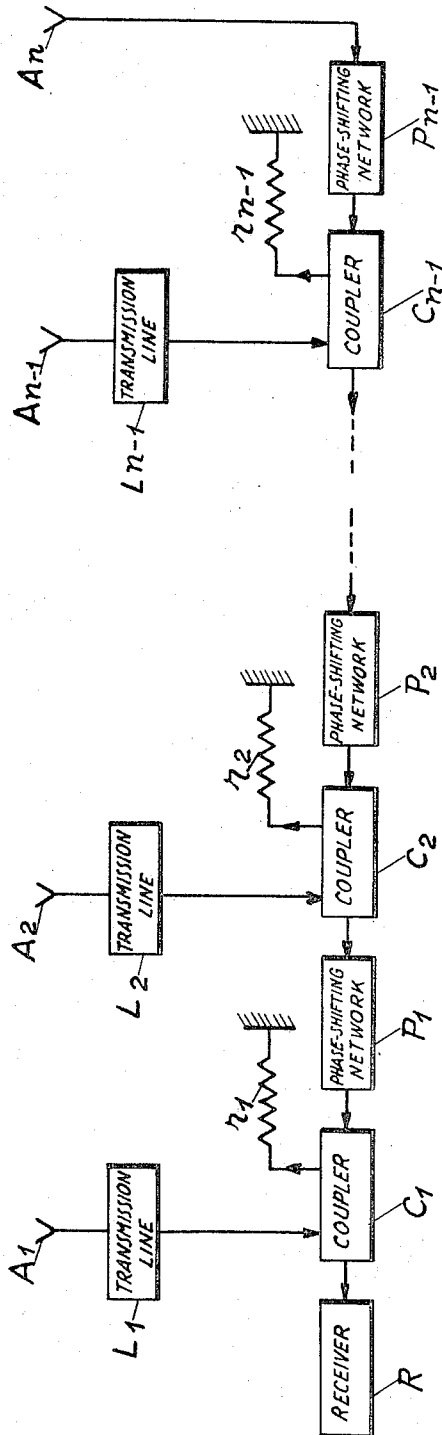


FIG. 6

INVENTOR
GERARD DUBOST

1

3,314,069

WIDE BAND DIRECTION FINDER ANTENNA
 Gérard Dubost, Paris, France, assignor to CSF—Compagnie Generale de Telegraphie Sans Fil, a corporation of France

Filed May 6, 1964, Ser. No. 365,434
 Claims priority, application France, May 7, 1963, 933,896;
 Apr. 23, 1964, 972,593, Patent 85,806
 6 Claims. (Cl. 343—119)

The present invention relates to broad-band direction finder systems, comprising two identical directional antennas or arrays of generally regularly spaced antennas. To determine a direction, the two radiation patterns have to be symmetrically inclined with respect to the bisector plane normal to the line joining the respective radiation centers. Generally the radiation patterns are inclined by an angle, which is constant whatever the operating frequency. However, this results in that, in the defined direction, the gain of each array varies to a substantial degree with frequency and the precision with which a direction is defined is quite variable.

It is an object of this invention to avoid this drawback. To this end the invention provides a circuit for dividing the energy fed to each array between the antenna elements building up this array with such relative phase shifts between the antenna elements that the ratio of the gain, in the direction defined by the system to the maximum gain of one array, remains constant within a wide band of frequencies.

The invention will be better understood from the following specification and appended drawings wherein:

FIG. 1 shows, very diagrammatically, a direction finder system according to the invention;

FIGS. 2 and 3 illustrate the gain variations of a conventional direction finder antenna system for two different frequencies;

FIG. 4 illustrates the phase shift between two antennas of an antenna system according to the invention as a function of the operating frequency for a uniform distribution of the applied energy between the elements of the array.

FIG. 5 shows one array of the antennas of a system according to the invention; and

FIG. 6 shows an array according to the invention comprising n antenna elements.

The system shown in FIG. 1 comprises two directive identical antenna arrangements A and A' of identical antenna elements a_1, a_2 and a'_1, a'_2 . Line p is the trace on FIG. 1 of the plane with respect to which the two arrangements are symmetrical. The antenna elements a_1 and a_2 or a'_1 and a'_2 are paced by d . The antenna elements of arrangement A are connected to a coupling circuit 5 and the antenna elements of arrangement A' are connected to a coupling circuit 5'. The arrangements A and A' are directive and their radiation patterns form an angle α . The coupling circuits 5 and 5' are respectively connected to the two inputs of a goniometric receiver 3.

In FIG. 2, the gain G of the two antenna arrangements has been plotted along the ordinates vs. the angle of the direction of the incoming signal, for a given inclination angle α of the radiation patterns and for a given frequency.

The direction defined by the abscissa θ_0 , i.e. by the intersection of the two radiating patterns, is the direction of the transmitter or reflector where the received signal originates. The gain in that direction is g_r .

In FIG. 3 the same plots were made for another frequency f' , all other things being equal.

It may be readily seen that, in spite of an increased directivity, the gain in the direction θ_0 has decreased.

2

Accordingly the precision with which the direction is defined also varies as a function of the frequency.

Thus, with the conventional practice of keeping constant the inclination of the radiating lobes with respect to their plane of symmetry, which is obtained by making the relative phase shifts between the antenna elements of each array proportional to the operating frequency, the gain of the antenna system in a given direction, and accordingly the precision, vary to a substantial degree.

In this respect, it may be shown that the amount of energy P received in the direction defined by the intersection of the two diagrams as shown in FIGS. 2 and 3, and accordingly the gain, other things being equal, varies substantially as the product φ, f, φ being the relative phase shift between the antenna elements of an array and f the frequency and it being assumed that each antenna receives the same energy amount. If φ is made proportional to f , gain G varies as f^2 , i.e. highly variable with frequency.

If, however, under the same power distribution, $|\varphi|$ is made to decrease while f increases, the gain will practically not vary with the operating frequency. The inclination of the lobes with respect to their plane of symmetry will then vary with the operating frequency, but this is not a drawback. If $|\varphi|$ is made to decrease linearly when f increases, a substantial constancy of the gain in the direction defined will be obtained.

In FIG. 4, φ has been plotted along the ordinates and f , which varies between values f_1 and f_2 , along the abscissae, still in the above mentioned case of uniform power distribution between the antenna elements of the array.

FIG. 5 shows an arrangement according to the invention in the same case, the array comprising two antenna elements.

Antenna a_1 , feeds the 90° input and antenna a_2 feeds the 0° input of a 90° directional coupler 1 through a phase shifting network 2.

The output of coupler 1 is connected to receiver 3. A suitable load impedance 4 is connected to coupler 1. Network 2 can be of the low-pass or high-pass type depending on the purpose the aerial system serves.

Network 2 introduces a phase shift which, together with the phase shift of the transmission lines needed in the circuit which varies with the frequency may be for all practical purposes, considered to be proportional to the operating frequency.

The signals picked up by the antenna element a_1 are thus received by receiver 3 with no phase shift (reference shift) while those picked up by the antenna element a_2 are picked up with a phase shift $-90^\circ + kf$, k being selected such that, in the operating frequency range, $-90^\circ + kf$ is negative. Coupler 1 may be of any type, provided it insures between the inputs and the outputs a 90° phase-shift of one of the signals relatively to the other.

By way of example, antennas A and A' may each comprise two elementary antennas covering about one octave between 2.3 to 4.3 gc./s., with a $\cos \theta$ radiation pattern, the antennas being spaced by 59 mm., the phase shift between the elementary antennas passing from 93° to 53° in absolute value as the frequency varies from 2.3 to 4.3 gc./s. and the maximum gain variation in the defined direction being ± 0.5 db, with a gain of about 2 db below the maximum.

In the most general case, i.e. when the distribution of power between the several antenna elements of each array is not uniform, the relative phase-shifts between these elements have to vary in different manners as a function of the frequency.

FIG. 6 shows an embodiment of the invention which

makes it possible to vary the phase-shift between any two adjacent antenna elements of the array according to the power amounts respectively radiated by the same. The arrangement is assumed to be a receiver arrangement. Of course the diagram would be the same with an emitter arrangement except that the direction of the arrows has to be reversed and transmitters have to be substituted for the receivers.

FIG. 6 shows an array of n antennas A1 to A_n . The array feeds the input of a goniometric receiver R.

The circuit comprises $n-1$ arrangements, each of them comprising in series a phase-shifting network P_i , with i equal to 1 to $n-1$, coupled to the first input of a directional coupler C_i . The $n-1$ arrangements are connected in series in such a manner that a first output of each coupler is coupled to the input of the adjacent network P_i . The output of network P_i is coupled to the first input of coupler C_i , and the first output of coupler C_i except for coupler C1, is connected to the input of network P_{i-1} .

The first input of coupler C1 is connected to receiver R.

Antenna elements A1 to A_{n-1} are respectively connected to the second input of couplers C_i through a suitable transmission line L_i while antenna A_n is directly coupled to network P_{n-1} . The second outputs of couplers C_i are grounded through respective matched loads r_i . The transmission lines L_i connect the elementary antennas A_i to couplers P_i .

By way of example, the following characteristic values were used in an arrangement according to the invention including two arrays of three antennas. The arrangement was operated successfully in a frequency band from $f_1=4.3$ gc./s. to $f_2=6.9$ gc./s.

The reference number (used hereinafter are those of FIG. 6, with $n=3$).

Phase-shifting network P1 introduces a phase-shift varying from $+31^\circ$ at f_1 , to -31° at f_2 ; phase-shift network P2 introduces a phase-shifting varying from $+7^\circ$ at f_1 to -7° at f_2 ;

C1: 4.8 db coupler

C2: 3 db coupler

L1 and L2: conventional connection transmission lines.

Under these conditions, antennas A1 or A3 radiate the same energy amount, equal to half the power radiated by antenna A2 and the relative phase shifts between the antennas are maintained constant and equal to 60° between antennas A3 and A2 and -60° between antennas A1 and A2. The variations of the phase-shifts introduced by networks P1 and P2 thus compensate the variations due to the transmission lines and the couplers. The gain in the defined direction was maintained 3 db below the maximum gain.

Of course, the invention is not limited to the embodiment described and shown which were given solely by way of example.

What is claimed is:

1. A wide-frequency band direction finder system comprising a first and a second directive array of elementary antennas, said arrays having identical radiation patterns with the same maximum gains and defining a given direction, and means for maintaining constant, within a given band of operating frequencies, the ratio of the respective gains of said arrays in said direction to said maximum gain.

2. A wide-frequency band direction finder system comprising a first and a second directive array of elementary

antennas and phase shifting means providing a phase shift between adjacent elementary antennas, whose absolute value decreases as the operating frequency increases.

3. A wide-frequency band direction finder system comprising a first and a second directive array of elementary antennas and means for coupling adjacent antennas to each other, said means comprising in series a directional coupler having at least a first, a second and a third terminal, the energy amount at said third terminal being equal to the sum of the energy at said first and second terminals with a relative phase-shift of 90° therebetween, and a phase-shifter whose phase-shift is frequency responsive, said adjacent antennas being coupled to said phase-shifter and to one of said first and second terminals respectively.

4. A wide frequency band direction finder system comprising: a first and a second directive array each of them comprising a first and a second antenna, a goniometric receiver, and a first and a second circuit for respectively coupling said receiver to said first and second arrays, each of said circuits comprising: a junction having a first input, a second input coupled to the first antenna and an output coupled to said receiver, means for coupling said second antenna to said first input, said means comprising a phase shifting network, whose phase shift characteristic is, in absolute value, a decreasing function of the operating frequency.

5. A wide frequency band direction finder system comprising: a first and a second directive array, each of them comprising a first and a second antenna, a transmitter, and a first and a second circuit for coupling said transmitter respectively to said first and second arrays, each of said circuits comprising: a junction, having an input coupled to said transmitter, a load, a first output corresponding to said input, a second output coupled to said first antenna, and means for coupling said first output to said second antenna, said means comprising a phase shifting network, whose phase shift characteristic is in absolute value a decreasing function of the operating frequency.

6. A wide frequency band direction finder system comprising a first and a second directive identical array of n adjacent elementary antennas, where n is an integer greater than one, and a first and a second circuit for respectively feeding said first and second arrays, each of said circuits comprising: $n-1$ "90° couplers" having respective first inputs, respective second inputs, respective first outputs and respective second outputs; $n-1$ respective transmission lines for respectively coupling the $n-1$ first antennas of the array to said second inputs of said couplers, $n-1$ matched loads for respectively grounding said second outputs of said couplers, $n-1$ phase-shifting network having respective inputs and respective outputs respectively coupled to said first inputs of said couplers, means for cascade coupling said phase shifting networks and said couplers by their respective inputs and outputs having the same number and means for coupling the n th antenna to said input of said $n-1$ st network.

References Cited by the Examiner

UNITED STATES PATENTS

3,134,977 5/1964 Takagi et al.
3,238,527 3/1966 Vogt.

CHESTER L. JUSTUS, *Primary Examiner*.
R. E. BERGER, *Assistant Examiner*.