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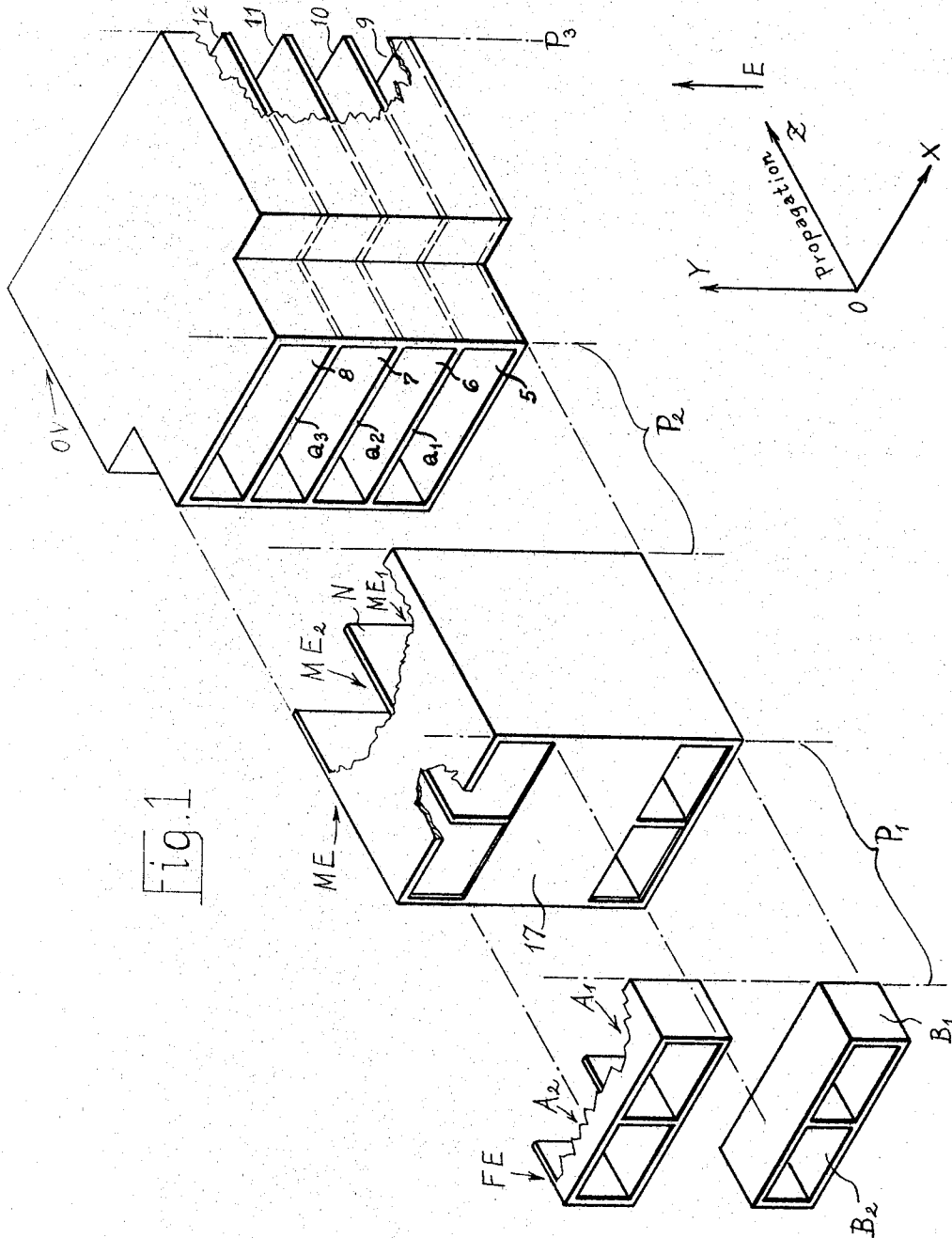
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3,308,469

MULTI-MODE ANTENNA SYSTEM

Filed Oct. 14, 1963

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

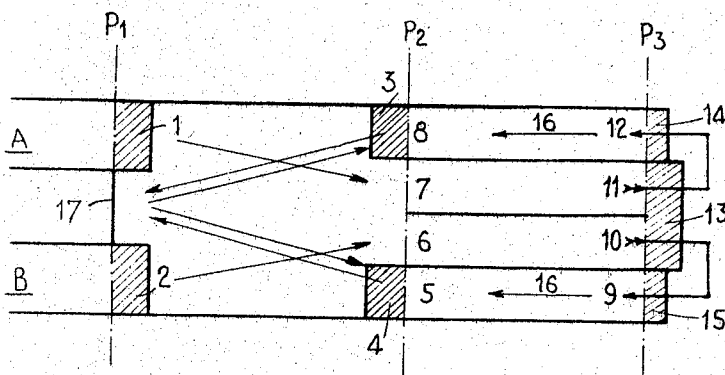


Fig. 2

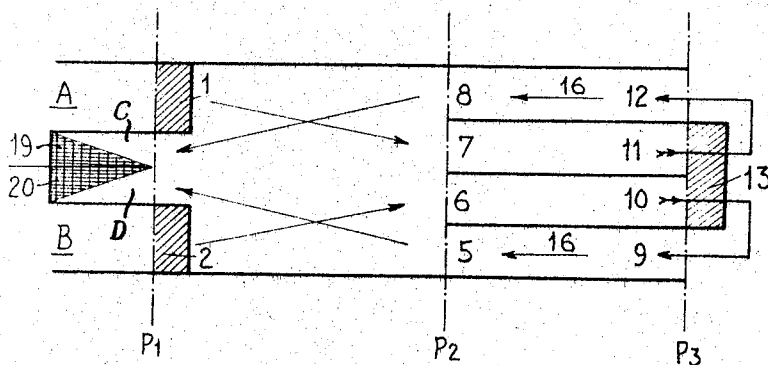


Fig. 3

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3,308,469

MULTI-MODE ANTENNA SYSTEM

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912,799, Patent 82,483

7 Claims. (Cl. 343-778)

This invention relates to UHF antenna systems of a type having means for controlling the radiation pattern thereof, herein designated as multi-mode antennas.

In my French Patent 1,290,275 I have described a UHF antenna array or system wherein the output radiation pattern of the antenna can be selectively controlled by modifying the input of exciting energy into the antenna. In the further development of my aforesaid prior invention I have found that certain practical defects are apt to arise under particular circumstances, and it is the general object of my present invention to reduce or eliminate such defects.

Objects of this invention, therefore, include the provision of an improved multi-mode antenna system having means for controlling the output radiation pattern thereof more closely and efficiently than was heretofore possible; to provide a multi-mode antenna array having means for minimizing pattern disturbance through undesired interaction between adjacent energy channels thereof; and to provide an improved UHF antenna array including in combination a plurality of input or exciter channels and associated absorbing channels for providing an improved controllable energy output. Other objects will appear hereinafter.

The invention will be described for purposes of illustration but not of limitation with reference to the accompanying drawing wherein:

FIG. 1 is a schematic exploded isometric view of a multi-mode antenna structure of the type to which this invention generally relates;

FIG. 2 is a simplified two-dimensional representation of the antenna structure shown in FIG. 1; and

FIG. 3 is a view similar to FIG. 2 showing an antenna system embodying the improvements of the present invention.

The general principle on which multi-mode antenna systems are based, for making possible a selective control of the output radiation pattern of the antenna, as disclosed in my French Patent 1,290,275, will first be briefly summarized. There are two fundamental concepts involved: (1) That the radiation pattern at the output of an antenna can be defined in terms of the distribution of electric fields at the radiating aperture of the antenna; and (2) that any selected electric-field distribution can be achieved by suitably superimposing a plurality of exciting electromagnetic waves, of predetermined mode, phase and amplitude characteristics, at respective parallel inputs of the antenna. Hence, by providing in a UHF antenna system means defining a plurality of separate wave channels in parallel all positioned within a common waveguide means and all terminating at a common radiating aperture and excited means connected with an input end of said waveguide means and operable for feeding thereinto input wave energy of separately selectable mode, phase and amplitude characteristics for propagation through said separate channels, the input wave energy fed to the respective channels will combine at said common radiating aperture to create thereat a preselectable radiation pattern.

A mathematical treatment of the above concepts will be found by referring to the aforementioned French patent.

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According to FIG. 1, which illustrates one typical structure embodying the earlier teachings just outlined, the structure extends along the axes of a trirectangular reference frame OXYZ in which axis OY is shown vertical and parallel to the electric vector of the incident wave energy; OX is horizontal and parallel to the magnetic vector of the incident waves; and axis OZ is parallel to the direction of incident-wave propagation. The structure comprises a feeder section FE, a so-called mode-selector section ME and an output section OV. Section ME is bounded by the transverse vertical planes indicated at P1 and P2, and includes a pair of wave-guide portions ME1 and ME2 positioned side by side and separated by a common vertical partition N. The mode-selector section ME controls the distribution of the electrical (E) vectors through the antenna. For this purpose the two portions ME1 and ME2 thereof are individually excited with input wave energy through respective pairs of input waveguides A1-B1 and A2-B2 forming part of feeder section FE. There is thus set up in the plane P2 at the outlet end of the mode-selector section ME a predetermined distribution of the electric field vectors. To ensure a persistence of this field distribution as far as the radiating aperture of the antenna system situated in the outlet plane P3, without substantial distortion thereof due to difference in propagation velocities between the different energy modes, the antenna structure beyond the plane P2 is subdivided vertically into several, here four, generally horizontal channels by spaced horizontal partitions Q1, Q2, Q3, serving impose a stratification on the electric field which is found effective to maintain the desired uniform law of field distribution in the vertical direction up to the outlet end of the antenna located in that plane P3. These channels have their inlets designated 5, 6, 7, 8 and their outlets designated 9, 10, 11, 12, respectively. It will be noted that the radiating aperture of the antenna system is, in effect, subdivided into a plurality of elementary apertures 9 through 12.

Thus, as indicated in the simplified diagram of FIG. 2, the hatched areas 1 and 2 represent the distribution of the vector intensity of the transverse field component in the plane P1, as produced by the input energy applied through the exciters or feeders A and B which are representative of the waveguide pairs A1, B1 and A2, B2 of FIG. 1. The areas 1 and 2 act as sources from which the wave energy propagates as indicated by the arrows into and through the channels 6, 7 in the output section of the antenna, so that at the outlets 10, 11 of said channels there is provided a field intensity as indicated by the cross-hatched area 13, representing the desired output field distribution, corresponding to a preselected output radiation pattern.

The above-described composite or multi-mode antenna structure operates satisfactorily to provide controllable radiation patterns in cases where the transverse dimension of the antenna is comparatively large and the number of parallel channels required is not too great in comparison. In other cases, however, there may exist a relatively high coupling factor between the respective channels at their outlet ends such as 9 through 12, so that the energy therein will interact and generate reflected waves which tend to propagate back towards the input end of the system and disturb the forward propagation of the incident waves. Specifically, with reference to FIG. 2, if it is assumed that a relatively close coupling is present between the outlets 9 and 10, and between outlets 11 and 12, then parasitic fields are present at the outlets 9 and 12, as indicated by the hatched areas 14 and 15. Energy generated from these parasitic fields propagates back as reflected wave energy along the arrows 16, producing corresponding fields in the plane P2 which, as indicated by the hatched areas 3 and 4, are distributed generally in

line with the field distribution in plane P1. This parasitic field distribution excites higher energy modes which propagate back towards the input plane P1 and create a concentration of energy at the central portion 17 of said plane. The central area 17 in turn reflects the energy mainly towards the areas 3, 4, with a phase condition varying with frequency. The resulting feedback of output energy reacts with the main flow derived from the input energy and causes cyclic disturbances having a beat character, in the shape of the radiation pattern as a function of frequency.

It will be understood that the above description with reference to FIG. 2 is schematic only and is not intended to provide an exact picture of the detailed phenomena occurring within the system. However, the above theory accounts satisfactorily in a general manner for the experimental finding that, owing to the largely unavoidable coupling present between the output channels of the antenna array, there is a feedback of parasitic energy which induces undesirable distortion in the otherwise satisfactory radiation pattern obtained with such a system.

In accordance with the present invention, the antenna system described above is modified so as to absorb all, or most of the unwanted feedback energy recycled into the system and thus to eliminate or reduce the aforesaid distorting effects. As shown in FIG. 3, the modification in this instance consists in removing the central section 17 in the input plane, between the feeders A and B, and substituting therefor an energy-absorbing unit. As shown, this unit comprises a pair of juxtaposed channels C and D leading upstream from the plane P1 and preferably containing absorbing material or impedance-matched loads 19, 20. In this way any wave energy reflected back towards the plane P1 from the output of the system because of coupling between the output channels is absorbed in the channels C, D and by the loads 19, 20, so that the feedback cycle is cut off and made ineffective. Practical experience has confirmed that the resulting output radiation pattern of the modified antenna is considerably more stable and undistorted, and can be made to correspond more accurately to a preselected pattern.

Preferably, the absorbing channels such as C, D are effectively decoupled from the adjacent input channels A, B through any suitable decoupling means of known character.

It may be noted that the structure in the input plane P1 of the improved antenna system according to the invention, as shown in FIG. 3, constitutes in effect a directional coupler.

It will be understood that the actual number and position of the absorbing or impedance-matched channels provided according to the present invention will depend on the particular construction of the multi-mode antenna system to which the invention is applied. While two such channels have here been shown, more may be required in some cases whereas in others a single absorbing channel may suffice. Generally speaking, the total number of additional absorbing channels used is equal to the number of degrees of freedom present in the particular law of irradiation with which the antenna system is to be used, as will be understood from the explanations given in my aforementioned French patent. Various other changes and departures from the single exemplary embodiment schematically shown herein and described above may be conceived without exceeding the scope of the invention.

What I claim is:

1. An antenna system comprising waveguide means having an output end defining radiating aperture means, a plurality of exciters connected with an input end of said waveguide means for feeding thereto input wave energy of separately selectable mode, phase and amplitude characteristics for propagation to said radiating aperture means, said waveguide means being dimensioned for simultaneous propagation of different modes of radiation from said exciters to said aperture means, and wave-ab-

sorption means within said waveguide means positioned and arranged for receiving and absorbing stray energy fed back into the waveguide means from said radiating aperture means, said exciters being spacedly juxtaposed in a transverse plane at said input end and said wave-absorption means is positioned between said exciters at said input end.

2. A system as claimed in claim 1, wherein said wave-absorption means includes at least one channel extending forwardly from said input end in the direction of propagation said channel being open toward said aperture means and decoupled from said exciters.

3. A system as claimed in claim 2, further including a radiation absorbing load in said channel.

4. A multimode antenna system having a selectively determinable radiation pattern produced by the superposition of a plurality of partial electric fields at a radiating aperture thereof, comprising:

waveguide means dimensioned to be capable of simultaneously propagating a plurality of different energy modes in a predetermined direction from an input end to an output end thereof, said output end forming a radiating aperture;

a plurality of feeder means connected to said input end for supplying thereto a plurality of components of wave energy simultaneously propagable with different modes through said waveguide means to create respective superposed partial electric fields simultaneously present at said radiating aperture, said feeder means forming channels with axes parallel to said direction;

wave-absorption means connected with said waveguide means for capturing and absorbing stray energy produced by spurious coupling between said partial fields;

and wherein said waveguide means is of rectangular cross section, said channels being in the form of a pair of rectangular feeder guides opening into said input end in transversely spaced generally symmetrical relation, said wave-absorption means being positioned in a central area of said input end between said feeder guides.

5. A multimode antenna system having a selectively determinable radiation pattern produced by the superposition of a plurality of partial electric fields at a radiating aperture thereof, comprising:

waveguide means dimensioned to be capable of simultaneously propagating a plurality of different energy modes in a predetermined direction from an input end to an output end thereof, said output end forming a radiating aperture;

a plurality of feeder means connected to said input end for supplying thereto a plurality of components of wave energy simultaneously propagable with different modes through said waveguide means to create respective superposed partial electric fields simultaneously present at said radiating aperture; said feeder means forming channels with axes parallel to said direction;

wave-absorption means connected with said waveguide means for capturing and absorbing stray energy produced by spurious coupling between said partial fields;

and wherein said waveguide means includes a rectangular waveguide section having a central longitudinal partition, said channels being in the form of rectangular feeder guides connected to the input end of said waveguide section and having narrow sides parallel to said partition, said feeder guides being arranged symmetrically on opposite sides of said partition and being spaced in a direction parallel to said partition, said wave-absorption means being positioned between said feeder guides.

6. A system as defined in claim 5 wherein said waveguide means further includes an output waveguide sec-

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tion extending from an output end of said rectangular waveguide section to said radiating aperture, said output section being formed with parallel longitudinal partitions extending in planes orthogonal to the plane of said central partition, thereby channeling said different components of wave energy during simultaneous propagation thereof to said radiating aperture.

7. An antenna system comprising waveguide means having an output end defining radiating aperture means, a plurality of exciters connected with an input end of said waveguide means for feeding thereto input wave energy of separately selectable mode, phase and amplitude characteristics for propagation to said radiating aperture means, said waveguide means being dimensioned for simultaneous propagation of different modes of radiation from said exciters to said aperture means, wave-absorption means within said waveguide means positioned and arranged for receiving and absorbing stray

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energy fed back into the waveguide means from said radiating aperture means, and a plurality of parallel propagation channels at said output end having inputs longitudinally spaced from and respectively confronting said exciters and said wave-absorption means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,308,469

March 7, 1967

Serge V. Drabowitch

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the printed specification, line 4, for "assignor to Compagnie Francaise Thomson-Houston," read -- assignor to Compagnie Francaise Thomson-Houston-Hotchkiss Brandt, --.

Signed and sealed this 7th day of November 1967.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents