DUAL BAND STATIONARY TACAN ANTENNA

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ABSTRACT OF THE DISCLOSURE

Two sets of directional antenna arrays in concentric ring configurations form a common coaxial support wherein one set is fixedly mounted on the support and the other set, which is adjustable in diameter relative to the support, has its elements displaceably radially through the spacings between elements of the fixed set to one position in front of the fixed set or to another position behind the fixed set. Each set has reflection means directed outwardly of the support; each set contributes part of the total band.

This invention relates to dual band compact antennas and more particularly to an omni-azimuthal beacon antenna for tactical air navigation (TACAN) systems.

TACAN generates a rotating directive omni-azimuthal radiation pattern. This pattern may be described as the sum of three components, (1) a carrier which has equal intensity 360 degrees in azimuth, (2) a first modulation component which modifies the carrier pattern to approximate a cardioid and (3) a second modulation component which adds to the cardioid pattern nine bidirectional amplitude variations of equal peak-to-peak amplitude, equiangularly distributed in azimuth. The radiation pattern is rotated at 15 revolutions per second in azimuth and is essentially unchanged in all orientations. An omni-directional reference pulse is radiated for each revolution of the pattern to mark one specific orientation of the pattern. Nine omni-directionally equally spaced reference pulses are radiated during each revolution of the pattern to mark one specific orientation of each of the nine amplitude variations. One of the nine reference pulses may be used for double duty, namely, to also mark the one specific orientation of the pattern during each revolution.

TACAN operates at around one thousand megacycles. The bandwidth requirement for a single TACAN channel or even several contiguous channels presents no problem in antenna design. However, as the number of channels and thus the bandwidth embracing all the channels is increased the antenna design represents more and more of a compromise manifested by poor performance on a large number of the channels. TACAN systems for aircraft carriers, for example, require too many channels for one antenna. Though one antenna has been used heretofore to get the equipment into operation, performance has been less than desirable on a large number of channels. More than one antenna assembly is not desirable. Furthermore, it is advantageous that the antenna be as compact as is practical consistent with the requirements of gain, uptilt, and high-angle coverage.

An object of this invention is to provide a compact UHF antenna, particularly a beacon antenna for TACAN, having wider high-performance bandwidth than heretofore.

A further object is to provide an essentially trouble-free compact wide band UHF antenna.

A further object is to provide a compact wide-band omni-azimuthal essentially trouble free, generally superior UHF antenna.

Other object and advantages will appear from the following description of an example of the invention, and the novel features will be particularly pointed out in the appended claims.

FIG. 1 is a side view partly in elevation and partly broken away, of a dual band antenna in accordance with this invention, and

FIG. 2 is a transverse sectional view taken on line 2—2 of FIG. 1.

The embodiment illustrated in FIGS. 1 and 2 is an omni-azimuthal beacon antenna for TACAN. It includes a metal tube support 10 which carries a first set of identical rod-like antenna elements 14 and a second set of identical antenna elements 16. While thirty-six elements are shown in each set, thirty-six is not essential, the number being related to radiation pattern specifications. The two sets are designed for respective frequency bands which together embrace all the channels of the TACAN system. Each antenna element includes a metallic tubular support that mounts an in-line vertically stacked series of dipoles. The metallic tubular support serves as a transmission line for the dipoles and as a reflector to provide more gain in an outward direction and as a shield against radiation in an inward direction. The antenna elements 14 are rigidly secured by mounting members 18 only one of which is shown in FIG. 1 to the support 10, equiangularly spaced, in a ring configuration coaxial with the column and with the dipoles directed radially outwardly. The antenna elements 16 are mounted on the support column with telescoping tubes 20, equiangularly spaced, angularly interleaved for meshing radially between antenna elements 14, with the dipoles directed radially outward. Ganging means link the antenna elements 16 in a ring configuration of adjustable radius, concentric with the set of antenna elements 14. The ganging means includes two rings 24 movable along the column 10, linked by a plurality of lead screws 26, only one of which is shown in FIG. 1, for movement toward and away from each other. A toggle type expansion assembly 28 joins each end of each antenna element 16 to a ring 24 and to the column 10. The ganging means is operable to adjust the antenna elements to two radial positions, outward and inward of the antenna units 14 as shown in FIG. 2. A simplified limit means in the form of a pin and slot 30 in each of the telescoping tube supports 20 defines the two radial positions. To more rigidly position the antenna elements in the outer or operating position, rigidly supported nesting means or sockets of dielectric material, not shown, may be provided for opposite ends of the antenna elements 16. To hold the antenna elements securely against shock and vibration in the retracted non-operating position, clamping means, not shown, may be provided for opposite ends of antenna elements 16. The reflecting supports of the antenna elements screen the non-operating elements from the operating elements. The lead screws are operable in unison by a motor-driven sprocket chain, not shown, engaging a sprocket gear 32 on each screw jack 26.

Modulating assemblies 34 and 36 for the two bands are connected coaxially to opposite ends of the column 10; the driven parts of the modulator assemblies are joined by a shaft that extends through the column 10. Coaxial cables 38 connect the antenna elements 14 to the modulating assembly 34. Coaxial cables 40 connect the antenna elements 16 to the modulating assembly 36. A modulating assembly of the type shown in U.S. Patent No. 3,066,291 may be used with this antenna. It is not essential to the dual band character of the invention that the modulating assemblies be secured to the column 10.

It is well known that arrays which are fed by transmission lines, as in this invention, provide the maximum directivity for overall dimensions, resulting in a consider-
ably smaller size than for the same gain and other characteristics obtained with horns or large passive directive systems. The transmission lines leading to the antenna elements, particularly elements, are flexible RF cables to accommodate the inward-outward movement.

Gain and upshift of the antenna elements are limited only by the requirements of physical size. Gain and upshift are improved in direct proportion to increased length of the antenna elements.

The two sets of antenna elements are displaced five degrees if there are thirty-six antenna elements in each set. The lobe structure produced by each set is dependent not on their orientation but on the orientation of the respective modulating systems with respect to their pulser plates. Therefore when switching bands, no orientation of the antenna system is required.

While this invention does not require more than one dipole on each reflector, in assemblies having the plurality of dipoles shown in FIG. 1, the following phasing arrangement is preferable. The 36 arrays of radiators for each band consists of four groups of two. Alternate groups are oppositely phased. More specifically, the center groups are of identical phase and with their reflector produce a radiation pattern of considerable directivity, over that obtained from a single dipole. Immediately on each side of this group are placed two radiators which are phased in opposition. These two radiators produce no signal along the perpendicular bisector of their support column but do produce a lobe above and a lobe below this line. These two lobes are of opposite phase. Combined in proper phase relation with the lobe produced by the center two antennas the energy below the perpendicular bisector tends to be cancelled while that above the perpendicular bisector is increased. Carrying this forward, the next set of radiators are fed in phase and the next set beyond are fed in phase opposition etc. This arrangement concentrates the energy slightly above the horizon while rapidly decreasing it at angles slightly below the horizon. The energy fed to the outer radiators is decreased in a ratio shown by the following equation to prevent large lobe production at angles far off the horizon.

\[ F = \cos(90^\circ \sin \theta - 45^\circ) + 7 \sin(270^\circ \sin \theta + 45^\circ) + 0.6 \cos(450^\circ \sin \theta - 45^\circ) + 4 \sin(630^\circ \sin \theta + 45^\circ) \]

This configuration results in an uplift on the horizon which is somewhat greater than 0.8 db for a departure of half a degree above to half a degree below the horizon. The arrays may be increased, limited only by the practical vertical height dictated by sighting requirements. In other words, instead of using eight radiators, any desired number can be used as far as electrical characteristics are concerned. This would result in no increase in modulation or rotating machine problems (the antenna being stationary).

The sideband or modulation decreases with the vertical angle. One means of improving vertical angle coverage is to decrease the carrier directed at high angles to bring the percentage of modulation up to more usable limits at higher angles. Another means is to use an auxiliary radiation system of somewhat larger horizontal dimensions than the main radiators which will not interfere with operation on the horizon but which will direct some sideband signal at higher angles.

It will be understood that various changes in the de-