United States Patent [19]

Pickles

[11] **3,795,914**

[45] **Mar. 5, 1974**

[54] **ROTATING BEACON ANTENNA WITH POLARIZATION FILTER**

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[73] Assignee: **E-Systems, Inc.**, Dallas, Tex.

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[52] **U.S. Cl.** ..... **343/756**, 343/106 R, 343/761, 343/774, 343/872

[51] **Int. Cl.** **H01q 19/00**

[58] **Field of Search**...343/756, 761, 839, 106 R, 744, 343/872

[56] **References Cited**

UNITED STATES PATENTS

3,054,106	9/1962	Parker et al.	343/761
2,979,719	4/1961	Avery et al.	343/761
3,261,018	7/1966	Mast	343/756

FOREIGN PATENTS OR APPLICATIONS

827,083	9/1957	Great Britain	343/756

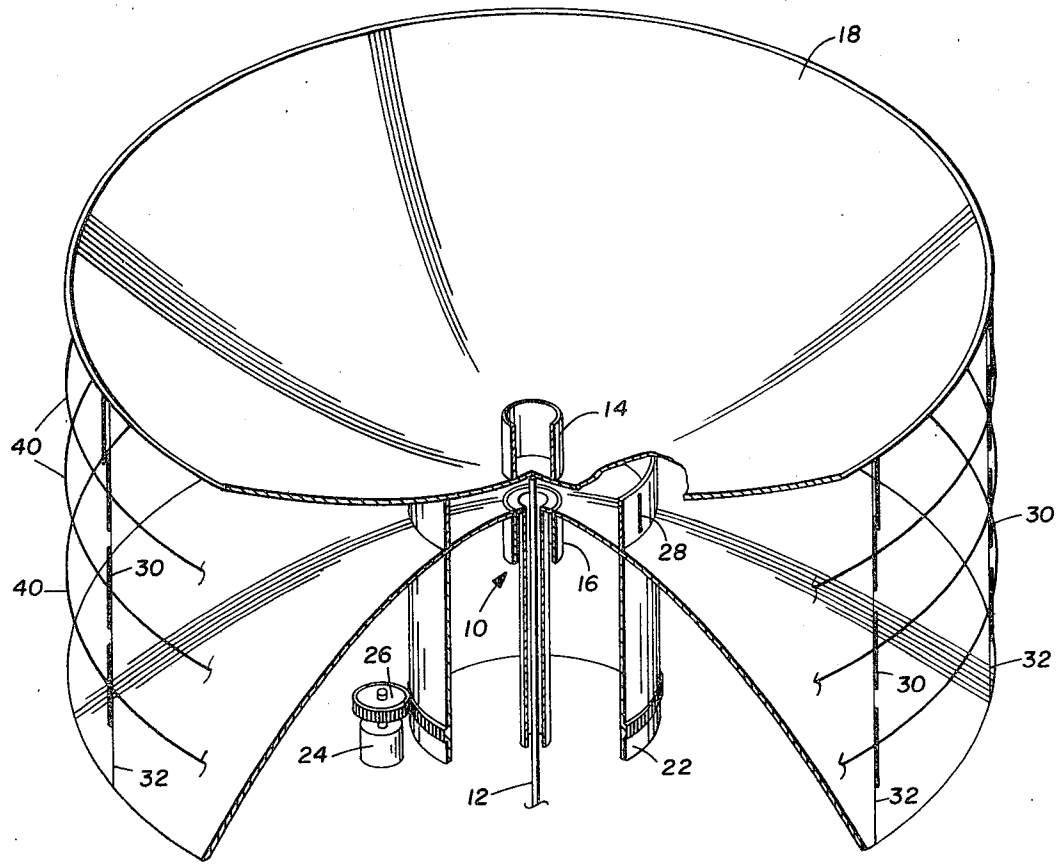
Primary Examiner—Eli Lieberman

Attorney, Agent, or Firm—James D. Willborn; Richards, Harris & Medlock

[57] **ABSTRACT**

TACAN antennas emit modulated radiation from parasitic reflecting elements associated with a central array having radiating elements coupled to an energizing source. Signal energy from the TACAN antenna is preferably radiated in a plane perpendicular to the surface of the earth. Cross polarization components of the radiated signal are absorbed by resistive wires located in the radiation path from the central antenna array. These resistive wires are mounted around the supporting structure of the TACAN antenna.

8 Claims, 5 Drawing Figures



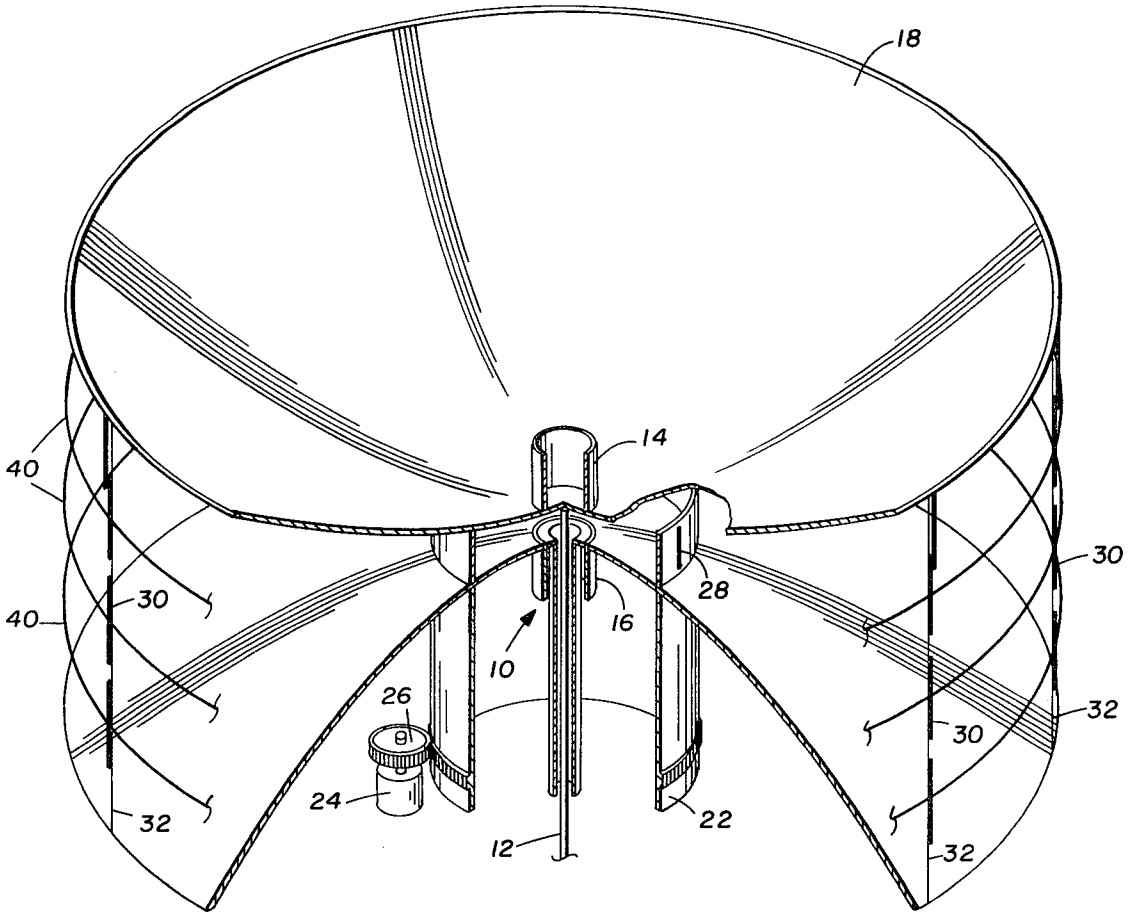

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FIG. 1

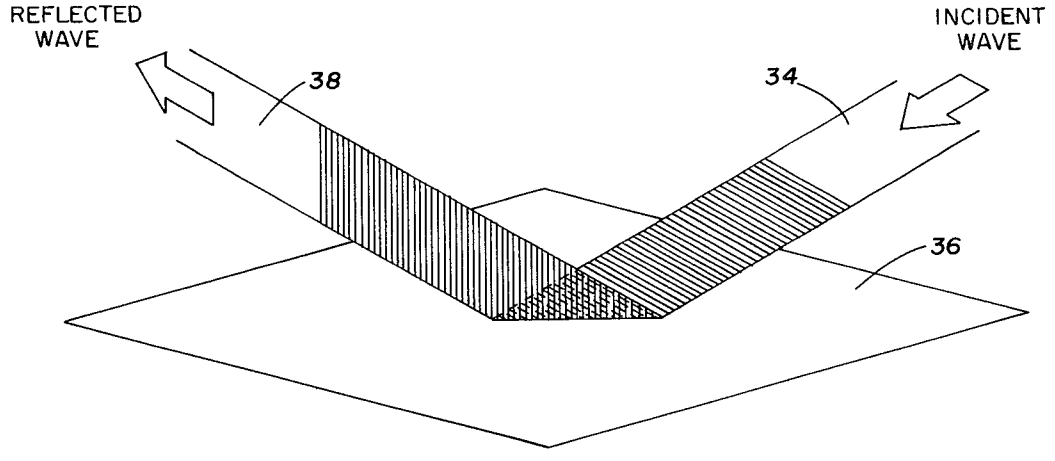

REFLECTED WAVE
INCIDENT WAVE
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FIG. 2

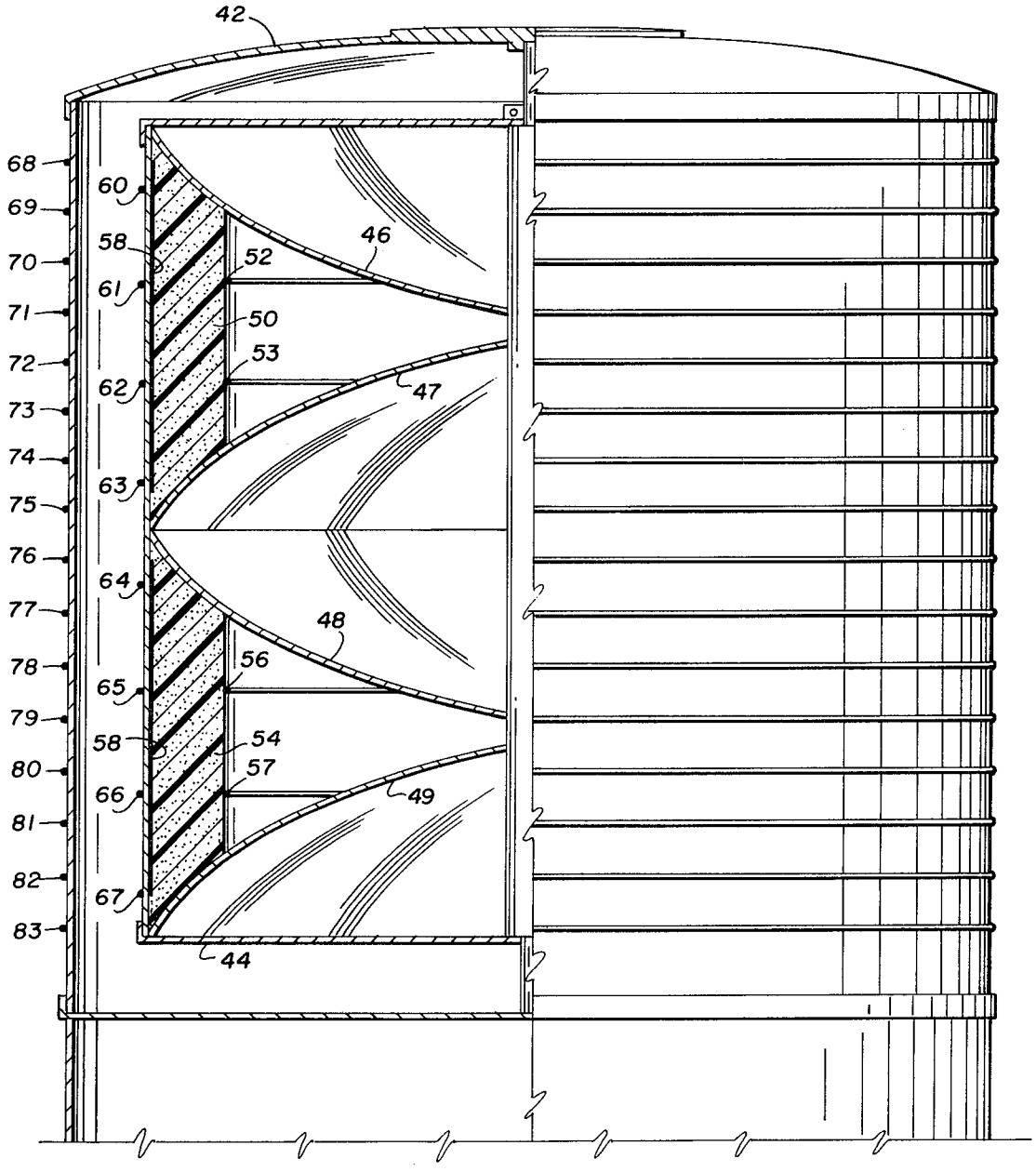

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FIG. 3

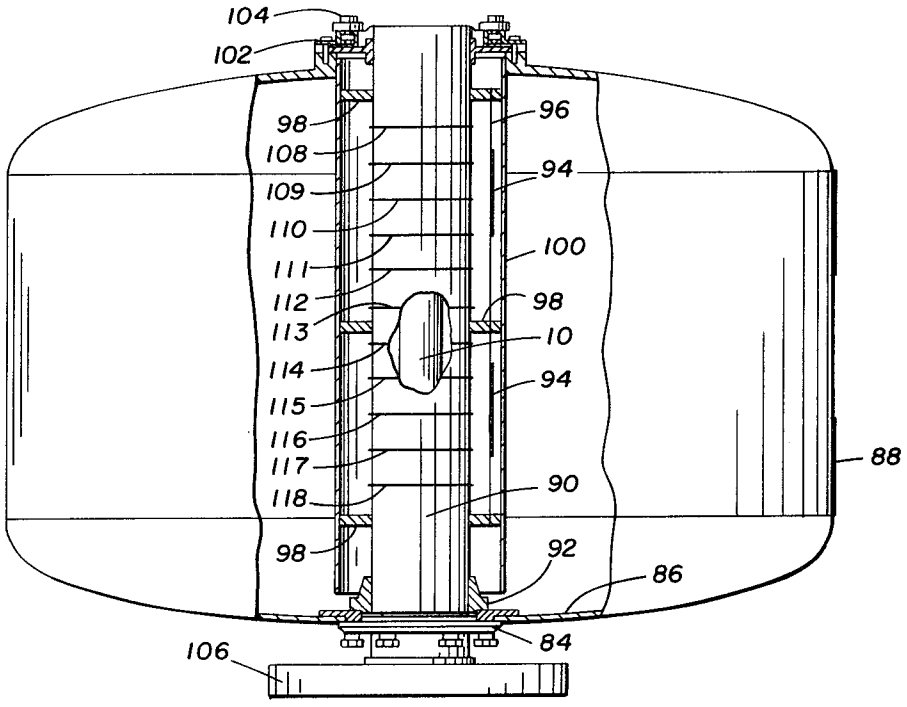

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FIG. 4

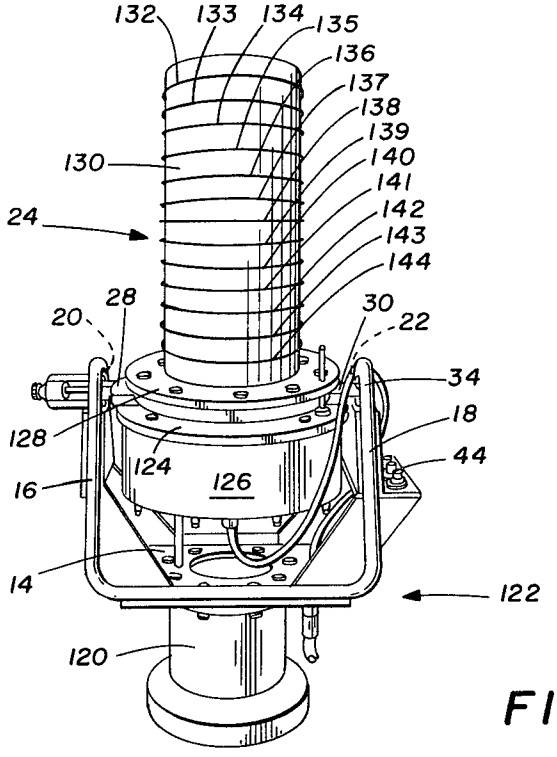

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FIG. 5

ROTATING BEACON ANTENNA WITH POLARIZATION FILTER

This invention relates to a system and device for eliminating or minimizing complex polarization radiation from an antenna structure, and more particularly to a system and device for absorbing radiation from a central array prior to reflection from oblique metal surfaces.

Beacon antennas producing a rotating multilobe pattern have been employed to radiate signals to distance measuring and radio navigation receiving equipment, these signals are modulated by rotation of parasitic elements around a central antenna array. One such antenna, commonly known as a TACAN antenna, is described in U. S. Pat. No. 2,803,821, issued to Sidney Pickles et al. Such an antenna employs a vertically disposed radiating element as a central array with one vertical parasitic element a given distance from the central array and additional parasitic elements equally spaced about the central radiating element, all at a second distance from the central array. As the parasitic elements are rotated about the central array, a rotating multilobe pattern of radiation is produced. Receiving equipment responsive to the radiation from the antenna detects a fundamental modulation of the beacon signal due to the rotation of the one parasitic element and a harmonic modulation due to rotation of the other parasitic elements.

As far as transmitting antennas are concerned, it is known that one part of the power delivered by a feed line, cable, wave guide or similar device to the antenna is radiated, another part is dissipated and another part is returned toward the central array by way of reflection. Various means have been devised in the past to eliminate, or at least to reduce, radiation reflection that produces a cross polarization radiation from the antenna. Known techniques include radiation absorbing devices that are mounted adjacent to the antenna to absorb radiation in a chosen direction.

Where such reflection radiation is allowed to be transmitted, a complex polarization pattern is transmitted to the receiving equipment of the air navigation system. Such complex polarization radiation contains navigational errors.

In an air navigation system, a receiver responds to modulations produced by the parasitic elements rotating about a central antenna array to obtain azimuth information at any point about the radiating station. The phase of the modulation at the receiving point with respect to an omnidirectionally radiated reference signal determines the obserber's azimuth. If the transmitting antenna produces radiation polarized in a plane other than the preferred vertical orientation, the modulation phase of the radiation polarized other than the desired direction may well be different from the correct modulation signal. Where a receiver knows of the cross polarization radiation, some corrective action may be taken. However, a receiver at a considerable distance from the transmitter antenna oriented so as to respond to the undesired signal, may indicate an azimuth different from the true azimuth from the direct radiated signal and not be aware of the error. This problem becomes particularly significant when the receiving equipment is airborne, and wherein the aircraft maneuvers into turns or banks which gives azimuth indications from time to time that differ substantially, producing uncertainty in the data presented.

A feature of the present invention is to obviate the above disadvantages by absorbing the reflected energy to minimize or eliminate a cross polarization component from a radiated pattern. In the case of an antenna consisting of a central array and parasitic elements, this result is achieved by displacing from the central array, in the region of parasitic elements, an absorber so that radiation is absorbed without reflection to structural surfaces that provide the cross polarization radiation.

In accordance with one embodiment of the invention, an antenna emitting a rotating multilobe pattern of radiation includes a central array having radiating elements coupled to an energizing source. A plurality of parasitic elements are disposed to revolve around the central array at a given radial distance therefrom to provide modulation of the radiation from the central array. Surrounding at least a portion of the parasitic elements is a radiation absorber for reducing complex polarization radiation from the antenna pattern.

A more complete understanding of the invention and its advantages will be apparent from the specification and claims and from the accompanying drawings illustrative of the invention.

Referring to the drawings:

FIG. 1 is a pictorial view of a biconical horn TACAN antenna employing radiation absorbing wires surrounding outer parasitic elements;

FIG. 2 is a pictorial representation of an oblique metal surface receiving incident radiation polarized in one direction and reflecting radiation polarized in a second direction;

FIG. 3 is a half-section of a biconical horn TACAN antenna employing multiple layers of radiation absorbing elements;

FIG. 4 is a cross-section of an antenna system having a rotating drum supporting parasitic elements for both 15 and 135 Hz modulation revolving about a central antenna array enclosed within a radome supporting radiation absorbing elements; and

FIG. 5 is a pictorial view of a shipboard mounted radio navigation antenna structure including radiation absorbing elements positioned on a protective radome.

Referring to FIG. 1, there is shown a biconical horn TACAN beacon antenna including a central antenna array 10 supplied energy through a coaxial type transmission line 12 supplying RF energy to the antenna. Typically, the transmission line may comprise an outer conductor and an inner conductor wherein said outer conductor provides a rigid support member as well as a conductor. Energy from the main transmission line 12 is fed to the central antenna array that includes choke joints 14 and 16 located at the apex of conical members 18 and 20, respectively. The central antenna array 10 may be a multi-element array consisting of two half wavelength dipoles stacked on top of one another. A pulsed radio frequency is fed to the antenna through the main RF feed transmission line 12. A more complete description of such a central antenna array may be found in the copending application of Sidney Pickles et al, Ser. No. 224,783, filed Feb. 9, 1972 entitled RADIO FREQUENCY ANTENNA SYSTEM, as assigned to the assignee of the present invention.

The lower conical member 20 is supported on a cylinder 22 of a dielectric material. This cylinder 22 is rotated by a drive motor 24 through a gear drive 26. The cylinder 22 (not shown in its entirety for purposes of clarifying the drawing) extends between the conical member 20 and the conical member 18 to provide a rigid structure between the two members 18 and 20. This cylinder between the members 18 and 20 has a length equivalent to one-quarter wavelength of the frequency energizing the antenna and transfers the rotating motion of the conical member 20 to the conical member 18. Thus, both the members 18 and 20 are rotated about the central antenna array 10 in accordance with standard TACAN antenna operation as described in the patent to Sidney Pickles referred to earlier or the previously identified application.

Radio frequency energy emitting from the central antenna array 10 has no directivity in the horizontal plane. To convey bearing information to a receiver, pulses from the central array are amplitude modulated. Such modulation is provided by two vertical parasitic elements 28 mounted to the rotating cylinder 22 between the members 18 and 20 and thus rotate about the central antenna array 10. Only one of the two parasitic elements is illustrated in FIG. 1. The distance between the central antenna array 10 and the parasitic elements 28 along with the speed of rotation of the drum 22 establishes the modulation frequency applied to the pulses from the central antenna array.

To improve the accuracy of bearing information transmitted from the central antenna array 10, a group of nine parasitic elements 30 are mounted to rotate with the parasitic elements 28 about the central antenna array. These nine parasitic elements 30 rotate around the central antenna array with the parasitic elements 28 and modify the cardioid radiation pattern from the antenna. As illustrated in FIG. 1, each of the nine parasitic elements 30 comprises three separate sections mounted to a supporting strand 32 extending between the conical members 18 and 20. It will be noted that depending on the radiation pattern required from the antenna system, the parasitic elements 30 could be a single element instead of the three section elements shown.

In addition to providing a rigid support for the parasitic elements 30, the conical members 18 and 20 also improve the gain and bandwidth of the antenna. However, the oblique metal surfaces provide an undesirable means of shifting the plane of polarization of signals radiated omnidirectionally from the parasitic elements 28 and 30.

Referring to FIG. 2, the shifting of polarization is illustrated with an incident wave 34, as radiated from the parasitic elements of the antenna of FIG. 1, striking an oblique metal surface 36, such as either of the conical members 18 or 20, and this energy is reflected as a wave 38. The signal in one plane of polarization as given by the wave 34 impinges on the metal surface 36 making an oblique angle with the plane of polarization of the incident wave. The plane of polarization of the reflected signal is shifted from the plane of the impinging signal. The reflected wave 38 may have a plane of polarization shifted by as much as 90° from the incident wave polarization; the degree of shift is an unknown making it difficult to provide a corrective adjustment.

A navigation aid receiver responding to energy from the antenna of FIG. 1 may be oriented such that the desired signal is rejected and the undesired signal processed giving wrong modulation phase and erroneous azimuth orientation direction.

To preclude radiation in any but the desired polarization plane, absorbing wires 40 are supported on the supporting strands 32 around the mouth of the biconical horn in a plane or planes at right angles to the normal plane of electric stress of the antenna. These wires 40 act as absorbers for unwanted polarization energy and minimize reflections from the parasitic elements 30 back to the oblique surfaces of the conical members 18 and 20.

Referring to FIG. 3, there is shown a half section of a biconical horn TACAN antenna modified from the antenna of FIG. 1. The TACAN antenna of FIG. 3 is enclosed within a stationary radome 42 of a fiberglass or other dielectric material. Within the radome 42, the antenna includes a rotating drum 44, also of a dielectric material, and conical members 46–49. Not shown in FIG. 3 is the central antenna array in accordance with standard TACAN antenna design.

Mounted within the mouth formed by the conical members 46 and 47 is a styrofoam support 50 having a cylindrical configuration and supporting on the inner wall thereof two absorbing wires 52 and 53. Similarly, mounted at the mouth formed by the conical members 48 and 49 is a styrofoam support 54 supporting on an inner wall absorbing wires 56 and 57.

Between the outer surface of the styrofoam supports 50 and 54 and the inner surface of the rotating drum 44 are 135 Hz parasitic elements 58. Additional parasitic elements 58 are spaced at 40° intervals around the interior surface of the rotating drum 44.

Mounted to the outer wall of the rotating drum 44 are absorbing wires 60–67. By properly spacing the absorbing wires 52–57 from the absorbing wires 60–67, improved absorption of reflected energy is provided. To provide maximum reflected energy absorption between the absorbing wires 52–57 and the absorbing wires 60–67, the styrofoam supports 50 and 54 have a cross sectional thickness of approximately one-quarter wavelength of the radiated energy. Providing a quarter wavelength thickness to the styrofoam supports 50 and 54 displaces the energy passing the elements 52–57 by 180° from the energy reflected by the absorbing wires 60–67.

To further improve the minimizing of reflected radiation from the conical members 46–49, absorbing wires 68–83 are supported on the outer wall of the stationary radome 42. Again, the spacing between the absorbing wires 60–67 and the absorbing wires 68–83 is such so as to provide 180° out-of-phase reflections between these two sets. To provide such a 180° out-of-phase displacement, the spacing between the outer wall of the rotating drum 44 and the outer wall of the stationary radome 42 is approximately one-quarter wavelength at the radiated energy.

In operation of the antenna of FIG. 3, incident energy from the central antenna array as reflected from the omnidirectional elements 58 strikes the absorbing wires 52–57. Here some of the energy is dissipated, some is reflected back in the direction of the source, and some proceeds on toward the next set of absorbing wires 60–67. At this point, energy from the first set of absorbing wires experiences further dissipation, reflec-

tion and transmission to the absorbing wires 68–83. It will be noted, that for each of the wires 52–57 there are two wires supported on the outer wall of the rotating drum 44. With this arrangement, the magnitude of reflection from the wires 60–67 may be a little larger than reflections from the wires 52–57 so that a wave of lesser size when either reflection is turned toward the central array.

Energy transmitted from the wires 60–67 strikes the wires 68–83 where it experiences additional dissipation, reflection, and transmission. Note again, that for each of the wires in the set supported by the rotating drum 44 there are two wires supported on the stationary radome 42. The reflection at the wires 68–83 is adjusted so as to reduce the size of the second reflection again by phase opposition. This reduced resultant then mates with the first reflection, as described, but on more equal terms resulting in a minimizing of reflection back to the energy source. After absorbing energy in the wires 52–57, 60–67 and 68–83, any remaining signal passing beyond the confines of the absorbing system is appreciably reduced from the original of the unwanted polarization. It should be noted, that energy at right angles to the plane of the absorbing wires in each of the various sets passes through the absorber system and induces no current therein. Hence, a wave polarized at right angles to the plane of the wires passes through the absorber system without attenuation.

Referring to FIG. 4, there is shown an antenna structure having high frequency and low frequency parasitic elements revolving about a stationary central antenna array. In this embodiment of the invention, the biconical members are not incorporated into the antenna structure; however, other oblique metal surfaces within the system will produce an unwanted cross polarization component without the absorbing wires as described.

Attached to the rotating shaft of a spin motor (not shown), such as described in the copending application of Sidney Pickles et al, Ser. No. 224,783, is a flange 84 that supports a rotating drum 86. As mentioned previously, preferably the rotating drum is of a thin dielectric material and is a spiral wound support for nine split sets of high frequency parasitic elements 88 (only one set shown). The nine sets of parasitic elements 88 are spaced around the drum 86 at 40° intervals, and, in the embodiment shown, are adhered to the outside surface with an adhesive.

Also rotating with the drum 86 is a support tube 90 by means of a collar 92. The support tube 90 supports the split low frequency parasitic elements 94 (only one set shown) on spaced filaments 96 extending between collars 98. Enclosing the entire assembly of the support tube 90 and the parasitic elements 94 is a guard 100 of a thin dielectric material. To maintain a spaced relationship between the drum 86 and the tube 90, the upper end of the tube is fitted with a positioning ring 102 fastened to the upper wall of the drum 86. Secured to this positioning ring are selectable balance weights 104 that are chosen to provide an equal weight balance to the structure.

The central antenna array 10 as shown in FIG. 1 connects to a coaxial cable through a connector in a conventional manner. The central antenna array 10 is stationary mounted with respect to a support plate 106.

Encircling the support tube 90 on the outer wall thereof are absorbing wires 108–118 adhered to the surface of the tube by an adhesive. Substantially polarization pure radiation is emitted from the central antenna array 10 and reflected from the parasitic elements 94; however, due to the inherent characteristics of the antenna array 10 and the elements 94, a small cross polarization component strikes the absorbing wires 108–118 wherein some of this unwanted component of energy is dissipated, some is reflected back in the direction of the source, and some proceeds outward from the antenna structure. After absorbing energy in the wires 108–118, any remaining cross polarization component of the signal passing beyond the confines of the absorbing system is appreciably reduced from the original of the unwanted polarization. The absorbing wires 108–118 also have an effect to minimize cross polarization resulting from radiation reflected from the omnidirectional elements 88 mounted to the drum 86.

Referring to FIG. 5, there is shown a radio navigation antenna as used with Distance Azimuth Measuring Equipment (DAME) systems. Typically, such antenna structures are used with a radio navigation systems for shipboard installations and are motion stabilized along an axis coinciding with the keel of the ship by means of supporting structure including an adaptor 120 conventionally attached atop the ship's mast. The adaptor 120 supports at its upper end a mounting yoke 122 including a mounting plate 124. Attached to the under side of the mounting plate 124 is a motor assembly 126 including a spin motor as described in the copending application of Sidney Pickles et al, Ser. No. 224,783.

Attached to the mounting plate 124 is a flange 128 that has bolted thereto a radome 130 enclosing a central antenna array and parasitic element assembly as shown and described in the application of Sidney Pickles et al, Ser. No. 224,783, except with conical shaped emitting elements instead of the cylindrical shape as illustrated. Mounted to the outer surface of the radome 130 are absorbing wires 132–144. These may be adhered to the radome 130 by means of an adhesive.

As radiated energy leaves the central array it illuminates the parasitic elements to provide amplitude modulation to the radiated energy. Some of the energy emitted by the central array from the oblique metal surfaces thereof is radiated in a direction to produce a cross polarization component. This energy strikes the absorbing wires 132–144 where the energy is attenuated such that any remaining cross polarization signal passing beyond the confines of the system is appreciably reduced from the original of the unwanted polarization.

While several embodiments of the invention, together with modifications thereof, have been described in detail herein and shown in the accompanying drawings, it will be evident that various further modifications are possible without departing from the scope of the invention.

What is claimed is:

1. An antenna emitting a rotating multilobed pattern of radiation, comprising in combination:

a central array having radiating elements coupled to an energizing source,

a plurality of parasitic elements disposed to revolve around said array at a given radial distance therefrom to provide modulation of radiation from said central array,

a first array of horizontal absorbing elements spaced about the periphery of the revolving parasitic ele-

ments on a first diameter to reduce complex polarization radiation from said antenna pattern,

a second array of horizontal absorbing elements spaced one-quarter wavelength from said first plurality on a second diameter to further reduce complex polarization radiation, and means for supporting said first and second array of absorbing elements on the first and second diameters.

2. An antenna emitting a rotating multilobed pattern of radiation as set forth in claim 1 wherein said first and second array includes a plurality of resistive wires spaced about the periphery of the revolving parasitic elements to absorb selected polarized radiation.

3. An antenna emitting a rotating multilobed pattern of radiation, comprising in combination:

a central array havin radiating elements coupled to an energizing source,

a plurality of parasitic elements disposed to revolve around said array at a given radial distance therefrom,

support means for positioning said plurality of parasitic elements coupled to a drive motor and rotated thereby to cause rotation of said parasitic elements around the central array for modulating the electromagnetic energy radiated therefrom,

a plurality of absorbing elements attached to said support means in proximity to said parasitic elements for reducing complex polarization radiation from said antenna pattern,

additional support means positioned between said first support means and said central antenna array, and

a second plurality of absorbing elements attached to said additional support means between said first plurality of elements and the central antenna array to further reduce complex polarization radiation.

4. An antenna emitting a rotating multilobed pattern of radiation as set forth in claim 3 including a stationary radome enclosing said support means and central array and including an additional plurality of absorbing elements spaced from said first plurality of elements around said stationary radome.

5. An antenna emitting a rotating multilobed pattern of radiation as set forth in claim 4 wherein said first, second and third plurality of absorbing elements are positioned horizontally to minimize a horizontal polarization component from the radiation pattern of said antenna.

6. An antenna emitting a rotating multilobed pattern of radiation, comprising in combination:

a drive motor,

a central array having radiating elements coupled to an energizing source,

a plurality of parasitic elements disposed to revolve around said array at a given radial distance therefrom,

support means for positioning said plurality of parasitic elements and coupled to said drive motor and rotated thereby to cause rotation of said parasitic elements around the central array for modulating the electromagnetic waves radiated therefrom,

a plurality of resistive wires attached to said support means in proximity of said parasitic elements for absorbing complex polarization radiation from said antenna pattern,

additional suppport means positioned between said first support means and said central array, and

a second plurality of resistive wires attached to said additional support means between said first plurality of elements and the central array to further absorb complex polarization radiation from said antenna pattern.

7. An antenna emitting a rotating multilobed pattern of radiation as set forth in claim 6 including a stationary radome enclosing said support means and central array and including an additional plurality of resistive wires spaced from said first plurality of elements around said stationary radome.

8. An antenna emitting a rotating multilobed pattern of radiation as set forth in claim 7 wherein said first, second and third resistive wires are positioned horizontally to minimize a horizontal polarization component from the radiation pattern of said antenna.

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