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United States Patent
Uhrig

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[54] **HELICOPTER UHF ANTENNA SYSTEM FOR SATELLITE COMMUNICATIONS**

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[73] Assignee: **The United States of America as represented by the Secretary of the United States Air Force**

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[21] Appl. No.: **149,495**

[52] **U.S. Cl.** **343/708,** 343/797, 343/872
[51] **Int. Cl.** **H01q 1/28**
[58] **Field of Search**...............343/705, 708, 797, 872

[56] **References Cited**

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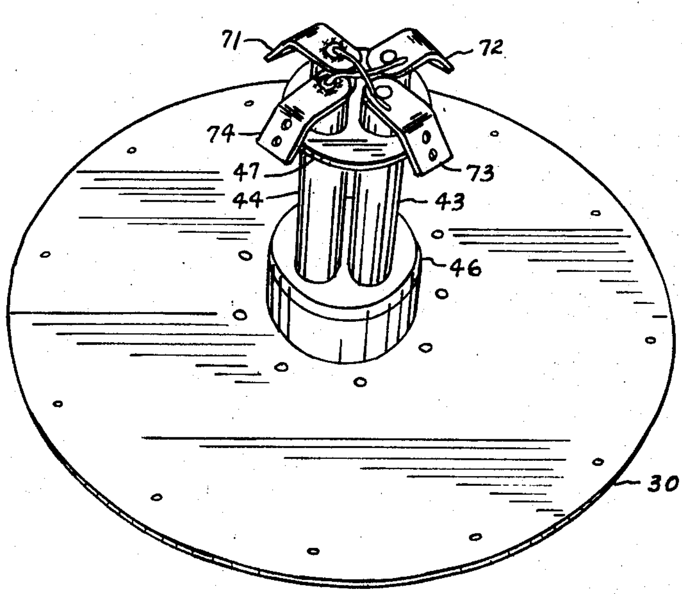
[57] **ABSTRACT**

A UHF antenna comprising crossed dipoles in the shape of drooped bow ties, encased by a polyester fiberglass laminated cone, positioned above and rotating with the blades of the helicopter, and orthogonally fed by a coaxial transmission line running through the hollow rotating mast provides an antenna for overhead signal transmission and reception. A coaxial rotary joint is placed inside the mast at the lower end to make a rotating electrical connection with the feed line.

2 Claims, 8 Drawing Figures



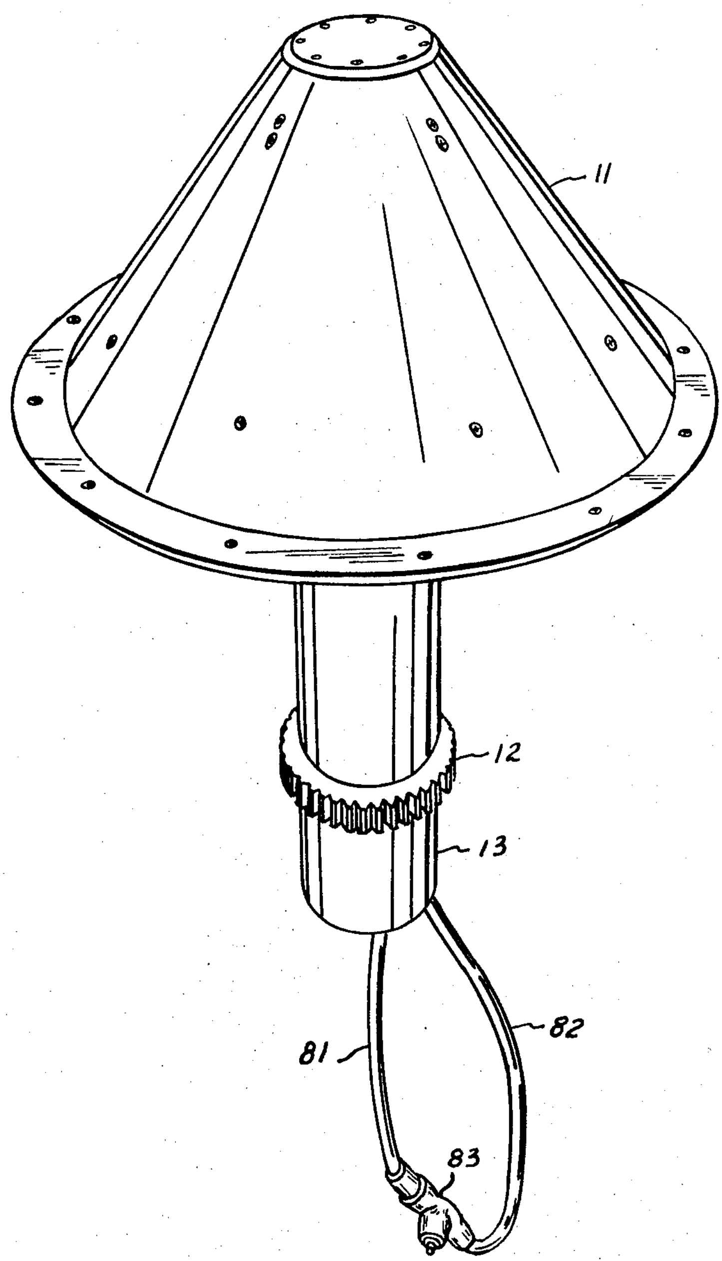


Fig-1

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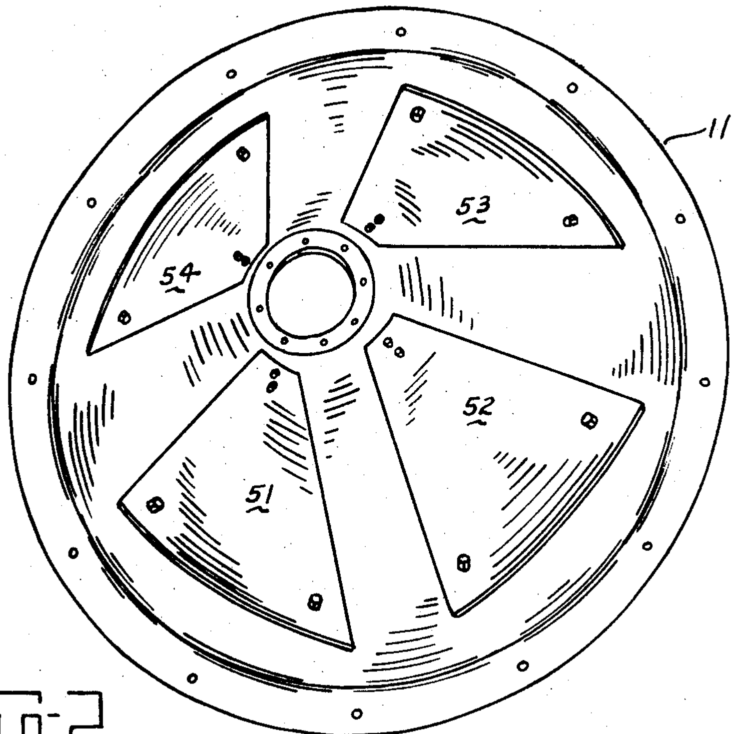

Fig-2

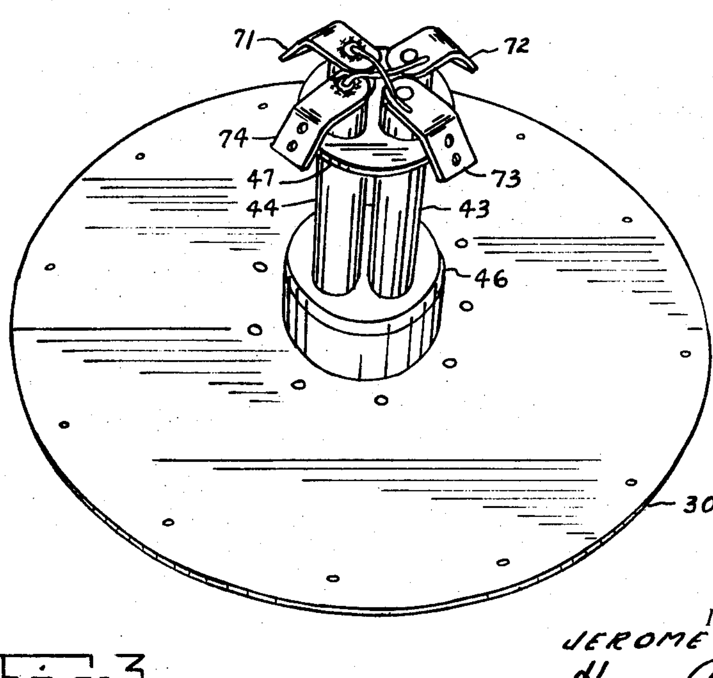

Fig-3

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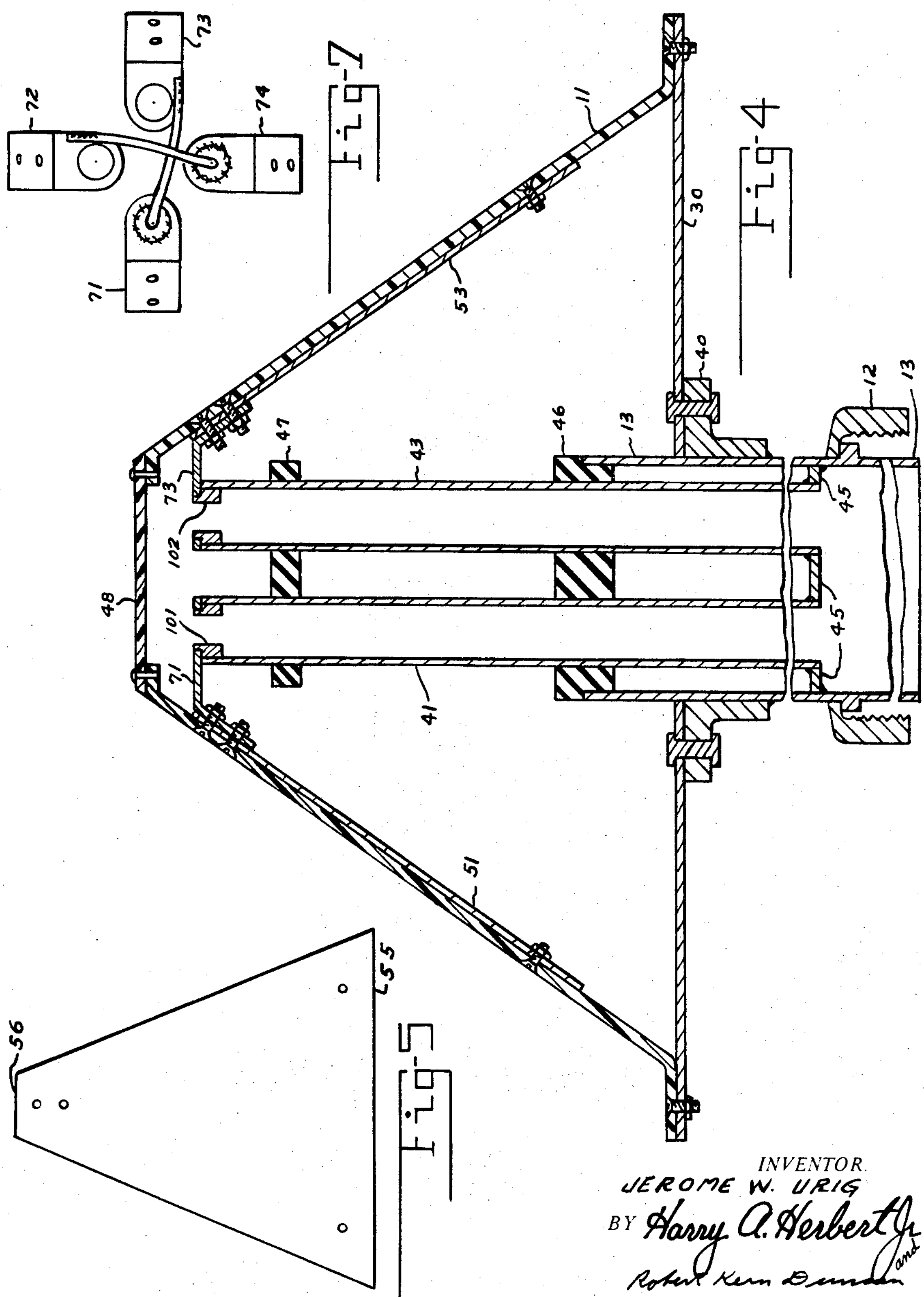

Fig-7

Fig-4

Fig-5

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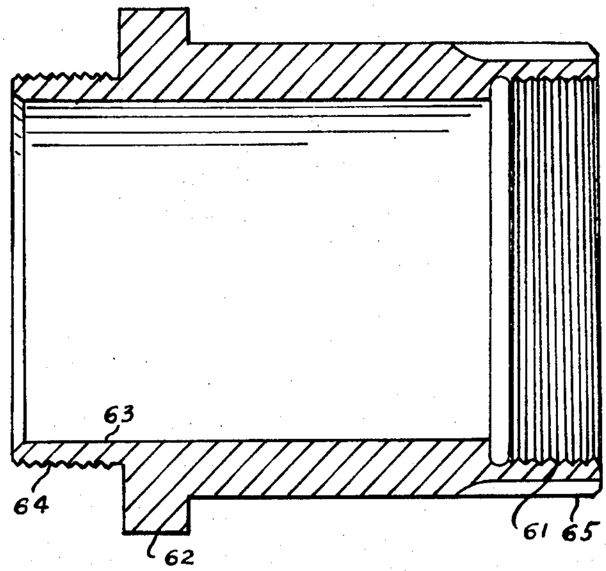

Fig-6

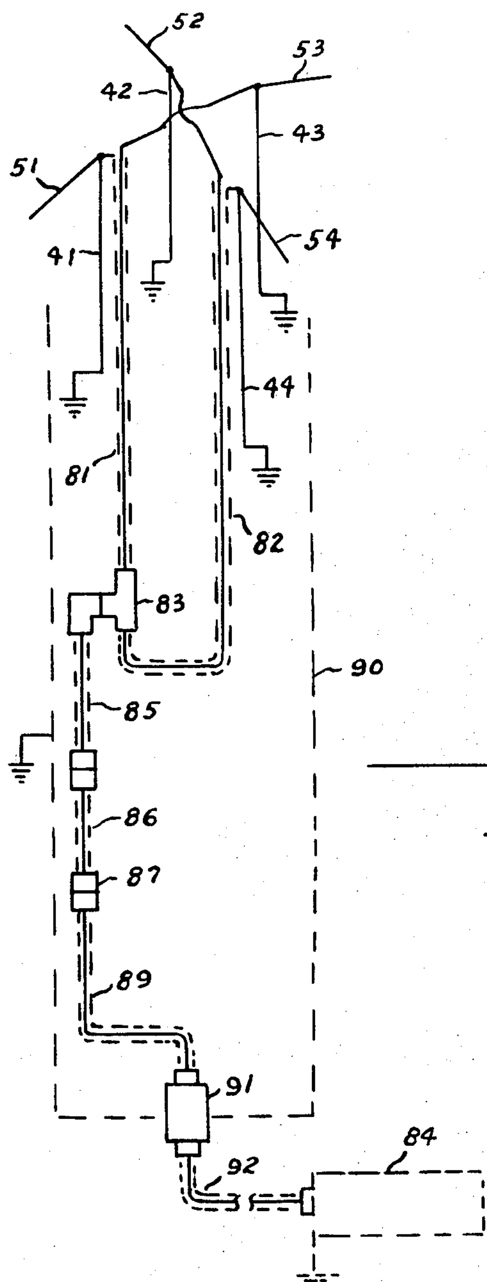

Fig-8

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HELICOPTER UHF ANTENNA SYSTEM FOR SATELLITE COMMUNICATIONS

BACKGROUND OF THE INVENTION

The field of the invention is in high frequency antennas for helicopters.

Both the mechanical and electrical rotation of antennas are well known. However, previous rotation, unlike that of the present invention, has been primarily to obtain a desired major direction of radiation (or reception). U.S. Pat. No. 3,045,236, "Rotatable Radomes for Aircraft" issued to P. A. Colman et al is a typical example of prior art of this nature. The conventional rotatable television antenna wherein the antenna elements are rotated to provide an increased gain in the direction of the desired transmitting antenna is well known. The closest known prior art to the present invention is U.S. Pat. No. 2,490,330, "Aircraft Antenna System," issued to A. E. Widle, Jr. In this patent the propeller blades of a conventional aircraft are used as the antenna elements. The use of the propeller blades as an antenna was to obviate the use of a trailing or fixed antenna and not to achieve UHF electromagnetic radiation from, or to, the aircraft in the direction through the propeller, as in the present invention. The similarity of this prior patent and the present invention is that the rotation of the antenna is ancillary of collateral to the function of the antenna.

Prior to this invention the problem of obtaining satisfactory communications via satellite link with airborne vehicles or ground stations from a helicopter has been serious. These communications are primarily in the UHF band of the electromagnetic radiation spectrum. On conventional fixed wing aircraft satisfactory communications via satellite link is readily accomplished by placing antennas on the top side of the aircraft. In this band (UHF), as is well known, communication is essentially via line-of-sight between the communicating antennas. On a helicopter having conventional antennas placed on top of the fuselage, communicating via satellite link (with the satellite overhead), the antennas are shadowed intermittently by the rotating blades above the ship. This is very undesirable for satisfactory communications.

SUMMARY OF THE INVENTION

The invention provides for helicopters an antenna system for UHF communications via satellite link in which the antenna is not shadowed by the rotating blade of the helicopters.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a pictorial view of the antenna structure that is placed on top of the helicopter mast;

FIG. 2 is a pictorial view showing the location of the bow ties inside the insulating and protecting cover;

FIG. 3 is a pictorial view of the base plate assembly showing the elements connecting with the bow ties;

FIG. 4 is a thin section view cut diametrically through two opposite elements with the details back of the cut omitted for clarity;

FIG. 5 is a developed view of one element of a bow tie;

FIG. 6 is a view of a mast nut for supporting the antenna;

FIG. 7 is a pictorial view of the electrical coaxial cable connections to the antenna elements; and

FIG. 8 is a schematic view of the electrical circuit of the antenna system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The antenna radiating elements are positioned on the inside of a protective insulating cover which is mounted on the top of a conventional hollow helicopter mast. (Radiating and radiation as used herein is to be construed in the broad sense covering both transmitting and reception.) This places the antenna above the helicopter blade, or blades, and the antenna rotates with the rotor of the helicopter. By the radiation elements of the antenna being above the rotor no chopping of the signal going to or coming from an overhead satellite occurs as with a conventional fuselage mounted antenna.

The specific embodiment set forth in detail is an antenna and system for the UHF portion of the communication band for a narrow band transmission frequency of approximately 303 MHz and a narrow band reception frequency of approximately 249 MHz. The standard practice is to use right circular polarization in the UHF band, thus the described embodiment is so connected. Left circular polarization is conventionally used for communication in the VHF band. For the X-band of frequencies right circular polarization is used going up (transmitting) and left circular polarization is used coming down (receiving) as a general practice. The disclosed system may readily be used for either right or left circular polarization or other frequency bands as will be described later.

Referring to FIG. 1, a pictorial view is shown of the antenna structure that mounts at the top of the helicopter mast. A polyester fiberglass laminated frustrum of a right circular cone **11** supports, protects, and insulates the enclosed drooped bow tie radiating elements. The preferred included conical angle is approximately 70°. An internally threaded ring **12** couples the structure to a modified mast lock nut as shown in FIG. **6**. To install the antenna on the hollow conventional helicopter mast, the conventional mast lock nut is removed and the modified mast lock nut shown in cross section in FIG. **6** is threaded onto the top of the mast in place of the conventional mast lock nut. The internal threads **61** engage the conventional external threads of the top of the mast. A hexagonal flange **62** provides a surface for engaging a wrench to tighten the modified mast nut to the required torque for safety. The modified mast nut locks to the helicopter mast in the conventional manner by a key stop meshing with the teeth **65**. The hollow tube **13** (FIG. **1**) slides into the modified mast nut along interior surface **63** and the antenna is fastened to the modified mast nut by tightening the internally threaded rotatable ring **12** on threads **64**. Ring **12** may also be locked by a set screw through the ring **12** engaging the modified mast nut.

As all the Figures of the drawing pertain to the same structure, including the schematic diagram of FIG. **8**, setting forth in detail one embodiment of the invention, identical reference numerals are used connoting the same structural elements in each figure.

An individual bow tie element is shown in FIG. 5. For the frequencies previous enumerated a lower base length 55 of approximately 6 inches, an upper base length 56 of approximately 1 13/16 inches, and a height between bases of approximately 6⅛ inches has been found to be preferred. These dimensions may be scaled up or down for other frequencies as is well known in the art. The bow tie elements may be fabricated from brass or any other high conductivity material as is commonly used in antenna structures. Four bow tie elements are formed to and symmetrically fastened on the inside surface of the cover 11 as shown at 51, 52, 53, and 54 in FIG. 2. The cover with the bow tie elements in place fits over the base structure shown in FIG. 3. The metallic (typically brass or aluminum) base plate 30 is fastened to the cover by machine screws located in the holes around the periphery of each, and by additional screws through the cover, the small ends of the bow ties, and the brackets 71, 72, 73, and 74. These brackets in addition make electrical contact with the bow ties 51, 52, 53, and 54 respectively.

A "no-depth" section view of the complete structure, less wiring, taken diametrically through the centers of bow tie elements 51 and 53 is shown in FIG. 4. A full half section showing all elements back of the section cut becomes confusing due to the multiplicity of lines, and since the structure is completely symetrical a "no-depth" section as is shown in FIG. 4 is much simpler and easier to readily comprehend. The metallic base plate 30 is at ground potential since it is rivited to aluminum bottom ring flange 40 which is welded to the shaft 13. The shaft 13 is mechanically coupled to the steel modified mast nut shown in FIG. 6 which is threaded onto the steel helicopter mast.

The four impedance balancing tubes 41, 42, 43, and 44, one connected to each bow tie radiating element, are connected together and to ground at their lower ends by metallic plate 45 which is soldered or brazed to the shaft 13. The tubes are further supported by teflon insulators 46 and 47. The top end of each impedance balancing tube is sweat soldered to their respective brackets 71, 72, 73, and 74, and the small supporting collar inserts 101, 102, 103, and 104. (Collars 101 and 102 only are shown in the drawing.) A polyester fiberglass cap 48 seals the enclosure.

In the specific embodiment being set forth in detail, for the frequencies enumerated the preferred length of the impedance balancing tubes from the top of the collars to ground ring 45 has been found to be approximately 9¼ inches (approximately an electrical quarter wavelength), and the distance from the top of the collars to the ground base plate 30 is approximately 6¼ inches (approximately a free space one-sixth wavelength).

In the embodiment being described the individual radiating elements of the dual crossed bow ties are physically spaced 90° apart thus by phasing each element 90 electrical degrees sequentially from the preceding one, that is, 0°, 90°, 180°, and 270°, a circularly polarized wave may be transmitted or received. The schematic diagram of the electrical system of this embodiment is shown in FIG 8. It is shown phased for transmission and reception of right circularly polarized waves. Opposite radiating elements are balanced fed 180° apart with the feed to the adjacent crossed elements electrically delayed 90°, to provide an orthogonal feed to the quadrature spaced radiating elements.

Fifty ohm impedance RG–87A/U coaxial cable is the preferred transmission line for this embodiment. It has an insulating cover over the outer conductor. Two pieces of coaxial cable 81 and 82 are run up through the impedance balancing tubes 41 and 44 of adjacent radiators. The outer conductor (braid) is soldered to the collars and brackets 71 and 74 connecting to radiating elements 51 and 54 and to impedance balancing tubes 41 and 44. The center conductors of these coaxial lines are connected to the respective opposite collars, brackets (73, 72), impedance balancing tubes (43, 42), and radiators (53, 52) respectively as shown in FIGS. 7 and 8.

To produce the 90° phase-shift between adjacent elements the coaxial line feeding one set of diametrically opposite radiators (having 180° therebetween) is made 90 electrical degrees longer than the coaxial line feeding the other set of opposite radiators. As shown in FIG. 8, coaxial line 82 is made a quarter wavelength longer than coaxial line 81, from the common signal coupling point at the conventional coaxial T-connector 83. In the embodiment being described for the frequencies previously stated and with the known propagation velocity in RG–87A/U cable this delay amounts to a cable length of approximately 6 11/16 inches. In a specific satisfactorily operating embodiment cable 82 is approximately forty and ½ inches long and cable 81 is approximately 33 13/16 inches long. The actual cable lengths and type of cable are not critical as long as a reasonably close impedance match with the radiating elements is maintained and power handling requirements are satisfied. The quarter wave delay is critical. Conventional communication sets 84 are designed for an antenna feed of approximately 50 ohms. In order to couple the two paralleled 50 ohm lines to the 50 ohm input to the set matching sections 85 and 86 must be used. Section 85 is approximately a one-third wavelength of 50 ohm cable (RG–87A/U) and section 86 is approximately a quarter wavelength of 75 ohm cable such as RG–140/U. In this embodiment the physical lengths are approximately 8.9 inches and 6.75 inches respectively. The impedance at the connector 87 appears as 50 ohms to properly match the communication equipment. Coaxial cable 89 is conventional fifty ohm cable (such as RG–87A/U) and of the length required to reach the bottom of the mast 90 where a conventional coaxial rotary joint 91 is positioned. A rotary joint is required as the antenna with the matching sections and coaxial cables contained inside the mast rotate with the mast as it drives the helicopter blade. Cable 92 going from the rotary joint to the communication set does not rotate. The rotary joint, the cable couplings, and the coaxial cable are all well known conventional pieces of communicating equipment.

While a specific embodiment for specific communicating frequencies has been set forth in detail those skilled in the art will readily adapt the invention to other frequencies by scaling the physical structures up and down to accommodate lower and higher frequencies. The electrical dimensions have been presented in terms of wavelengths, as well as physical measurements for the specific embodiment, to further aid in practicing the invention at other frequencies. Obviously, left handed circular polarization may readily be obtained by merely making cable **81** one quarter wavelength longer than cable **82**. The direction of rotation or movement of the helicopter mast is immaterial to the radiated (or received) wave. In the embodiment described in detail the VSWR (voltage-standing-wave-ratio) on line **92** to the communication set is typically 1.48 at 249 MHz and 1.18 at 303 MHz.

I claim:

1. An antenna system, for a helicopter having a hollow rotor mast, for communicating via overhead satellite link, comprising:

a. dual crossed bow tie radiating elements positioned on the top of the said rotor mast and rotating therewith;

b. means cooperating with the interior of the said hollow mast and rotating therewith for orthogonally feeding the said radiating elements for circularly polarized radiation; and

c. means for electrical coupling from exterior the said mast to the means for orthogonally feeding the radiating elements.

2. An antenna system for communicating with a conventional communication set from a helicopter having a hollow rotor mast via overhead satellite link, the said communication set having a determined connecting impedance comprising:

a. drooped, dual, crossed bow tie antenna radiating elements, quadrature spaced, enclosed in an insulating protective cover;

b. means including a hollow tube cooperating with the said enclosed antenna radiating elements and the said rotor mast for axially positioning the antenna in fixed relationship on top of the rotor mast;

c. means cooperating with the said antenna elements extending into the said hollow tube for orthogonally coupling the said antenna elements and providing a common point of signal coupling;

d. means including an electrical quarter wavelength of coaxial cable for matching the electrical impedance at the said common signal coupling point to provide the said connecting impedance of the communication set, the said matching means being contained within the hollow rotor mast; and

e. means including a coaxial rotary joint positioned at the bottom of the said rotor mast, for coupling the said communication set to the said matching means.

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