June 15, 1965 J. J. KULIK ETAL 3,189,906

SHIPBOARD CONICAL ANTENNA WITH CONDUCTIVE SUPPORT MAST

Filed May 24, 1961 2 Sheets-Sheet 1

FIG. 1

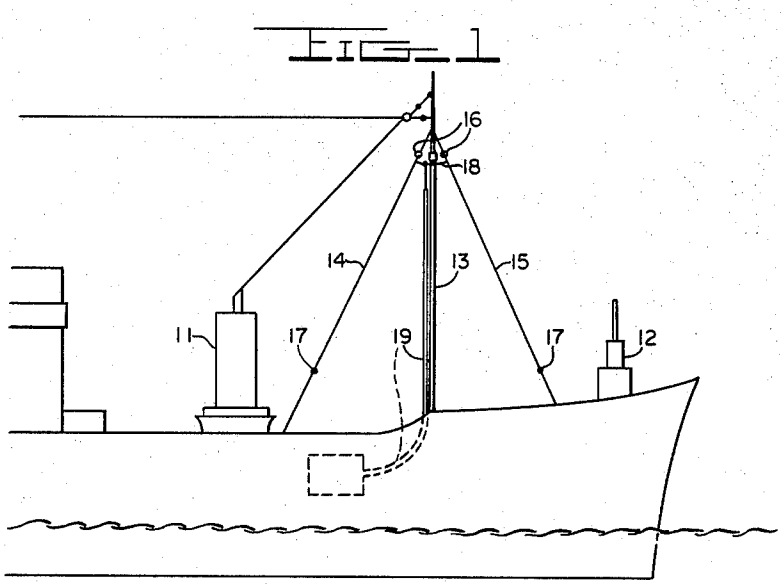


FIG. 2

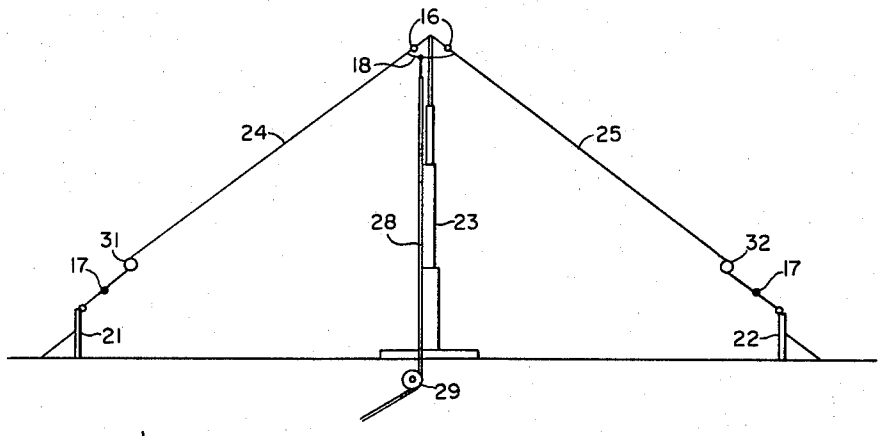
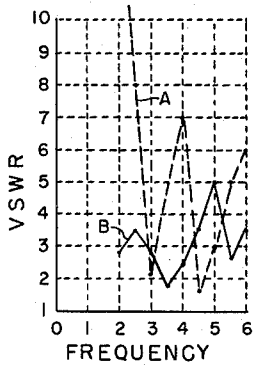


FIG. 3



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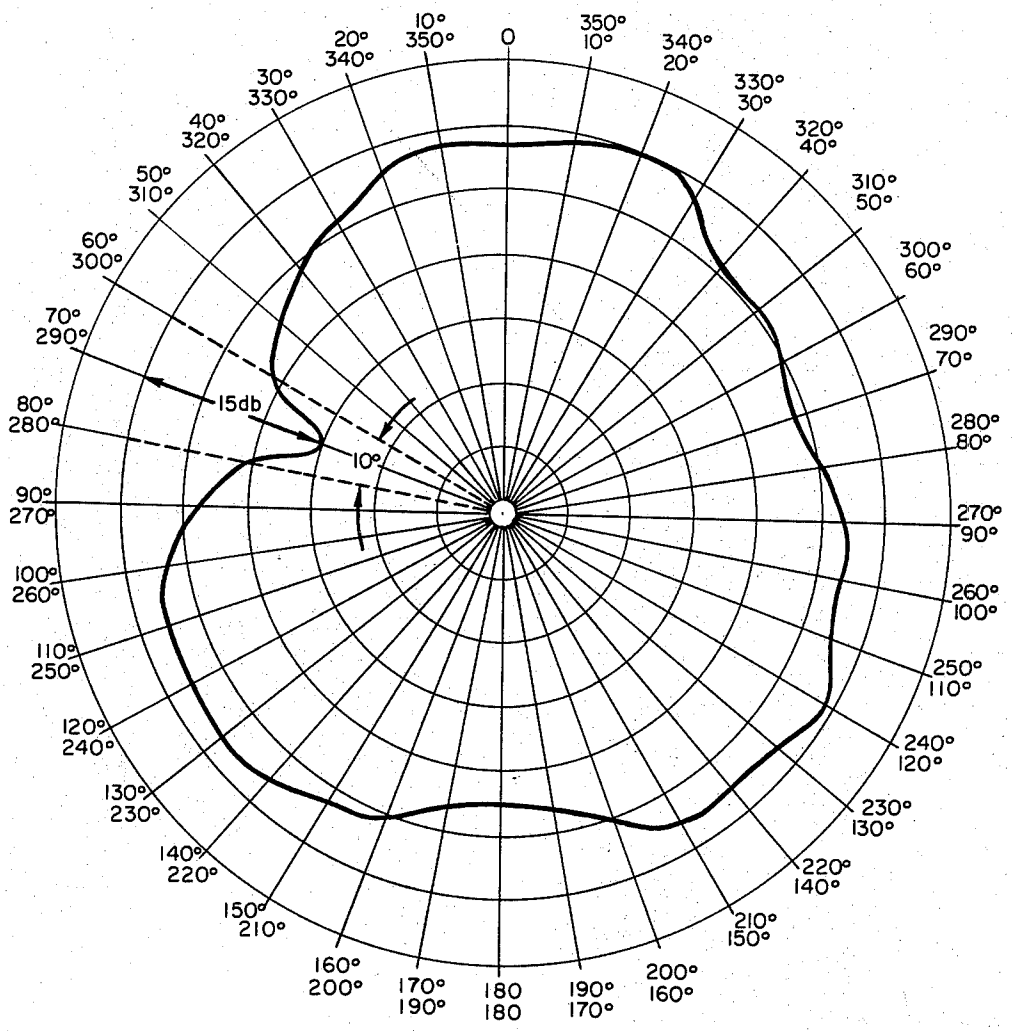
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FIG. 4



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SHIPBOARD CONICAL ANTENNA WITH CONDUCTIVE SUPPORT MAST

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7 Claims. (Cl. 343—710)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates in general to antenna systems and in particular to broadband antenna systems for shipboard use and the like.

It is generally recognized that antenna congestion is undesirable in that it usually leads to extensive cross coupling, severe pattern-distortion, uncontrollable interaction between closely spaced antennas, and other factors which contribute to radiation inefficiencies.

The ever increasing amount of radio communication equipment aboard naval vessels has placed greater emphasis on the application of multicoupler and broadband antenna techniques whereby the number of antennas may be minimized.

Heretofore shipboard communication antenna for use at low frequencies (under 2 mc.) have been relatively simple in design, for example, of the long wire variety. The principal problem at low frequencies has been one of structural limitations, length of ship, height of mast, etc. At higher frequencies (above 2 mc.) dimensional restrictions are reduced to some extent, but the problems of interaction aboard ship are magnified and more complex broadband antenna designs have been employed to minimize this problem. It is common practice at present to employ a sleeve antenna design at higher frequencies wherever practicable to do so. A sleeve antenna has offered a satisfactory solution in many applications, however, it does not, in itself, afford the tolerable maximum 3:1 SWR (standing wave ratio), and as a general rule an impedance transformer or lumped constant circuit must be incorporated to achieve the tolerable SWR results. Considering the usual inter-coupling problem, it will be appreciated that impedance matching design can not be predicted as a general rule and that each impedance matching design must be adapted for its particular antenna application. Thus the impedance matching means becomes an integral part of each antenna and this incorporation adds considerably to the cost thereof.

It has long been recognized that a broadband antenna particularly useful in the frequency range above 2 mc. having a desirable standing wave ratio without the need for a custom designed transmission line transformer or the like, and adaptable to shipboard installations is needed and would be welcomed as a substantial advancement of the art.

Accordingly, it is an object of this invention to provide an antenna which is readily adaptable at minimum expense to vessels now afloat.

It is an additional object of this invention to provide a broadband antenna which naturally affords a tolerable standing wave ratio at 50 ohms over a selected band of frequencies.

It is a further object of this invention to provide a broadband antenna which may be speedily assembled and/or hoisted into position as needed.

It is another object of this invention to provide a broadband antenna for shipboard installation which does not substantially obscure vision.

It is still another object of this invention to provide a

broadband antenna which utilizes a minimum of deck space.

Other objects of the invention will become apparent upon a more comprehensive understanding of the invention for which reference is had to the following specification and drawings wherein:

FIG. 1 is a pictorial showing of one embodiment of the antenna of this invention in a typical shipboard installation.

FIG. 2 is a pictorial showing of another embodiment of the antenna of this invention in a typical multipurpose installation.

FIG. 3 is a graphical showing of the VSWR characteristic for a conventional sleeve antenna and for the antenna of the present invention.

FIG. 4 is an azimuthal showing of a typical radiation pattern for the antenna of this invention in a shipboard installation of the type shown in FIG. 1.

Briefly, the device of this invention is a unique antenna of the conical variety having a metal shaft core, radiating elements which serve to brace and to support the metal shaft in an upright position on a surface and an apex feedpoint whereby a smooth impedance match and a tolerable SWR characteristic is obtained. As an additional feature, the antenna may be designed for ready assembly or quick hoist into position as needed.

Referring now to the drawings in detail:

In FIG. 1 the forward section of a ship is depicted with several conventional prior art sleeve antenna and an antenna of the present invention installed thereon. This depicted combination of antennas is for purposes of comparison and it will be appreciated that the use of a sleeve antenna in conjunction with the antenna of the present invention is not essential to the operation of the antenna of the present invention. Rather, the antenna of the present invention is often a substitute for the sleeve antennas shown. It will be noted that the larger sleeve antenna, indicated at 11, presents a significant obstruction to the field of view from the bridge of the ship. Likewise the smaller sleeve antenna, indicated at 12, presents an obstacle to the viewer which is of lesser proportion but often interferes in the course of docking operations, for example. In contrast, the antenna of the present invention, which may utilize the metallic foremast of the ship, indicated at 13, and the guy wires attached thereto, afford no additional obstacle to the field of vision from the bridge.

In the embodiment of FIG. 1 the foremast, 13, is supported by guy wires, indicated at 14 and 15, each of which includes upper and lower strain insulators, indicated at 16 and 17, respectively, to isolate the guy wires from the metallic foremast, 13, and from the deck of the ship. The isolated center sections of each of the guy wires form the radiating elements in this antenna and are electrically connected at the upper end by the connecting cable indicated at 18. The antenna is fed by means of a coaxial transmission line, or the like, indicated at 19, which runs from the communication equipment, not shown, up the foremast to the connecting cable 18 where the center conductor of the coaxial line is electrically connected to the cable 18. In this embodiment, the outer conductor of the coaxial line may be and for best performance generally is grounded along its length to the foremast 13.

In such embodiment as that shown in FIG. 1, the antenna may be employed as a transmission antenna, as a reception antenna, or as a combined transmission and reception antenna. In cases where the antenna is to be used for transmission purposes, the lower strain insulator is normally installed at a point sufficiently above the deck surface to minimize the possibility of accidental personnel contact with the radiation elements during high

power transmission. The length of the radiation element is determined by center frequency wavelength subject, of course, to physical limitations involved in the particular installation. While two guy wires are indicated in FIG. 1, it will be appreciated that in a conventional installation perhaps four guy wires would be employed to brace the foremast and that in such a case each of the guy wires generally would be employed as radiation elements. As a practical matter, it has been found that at least three guy wires are required to provide a substantially uniform omnidirectional radiation pattern.

FIG. 2, depicts another embodiment of the invention which is particularly suitable for installation where the foremast of a ship or other comparable superstructure such as the "island" of an aircraft carrier is not normally available. In a submarine installation, for example, where it is desirable to keep topside equipment to the minimum such that undetected subsurface operation is practicable, the embodiment of FIG. 2 would be especially suitable. As is well known, it is standard practice to provide retractable upright structures such as periscopes, whip antenna and the like in such installations. In FIG. 2 a retractable mast 23 of the telescoping variety is shown supporting the guy wires 24 and 25 which are each isolated from the grounded mast and deck by strain insulators 16 and 17 respectively. Braced guy wire support masts 21 and 22 are provided to maintain the radiating elements at a safe height and for other reasons to be explained hereinafter. Spring loaded reel units 31 and 32 are provided in the depicted embodiment at the lower end of the guy wires 24 and 25 to permit a variation in effective length of the guy wires as the height of the retractable mast 23 is varied, while the reel units 31 and 32 are shown above the insulator 17, it will be appreciated that they might, alternatively, be installed below the insulator 17, if desired. As in the embodiment of FIG. 1, the upper ends of the guy wires are electrically connected by connecting cable 18 and the antenna is fed by means of coaxial transmission line 28 which runs from the communication equipment, not shown, up the mast to the connecting cable 18 where the center conductor of the coaxial transmission line is electrically connected to the cable 18. Transmission line 28 includes a reel means 29 which enables extension of the transmission line as the mast is extended and takes up the slack as the mast is withdrawn.

While the embodiment of FIG. 2 shows reel units 31 and 32 at the lower end of the guy wires 24 and 25 it is appreciated that one or more reel units at the upper end of the guy wires 24 and 25 might be substituted therefore provided, of course, such reel units did not interfere with the means provided for isolating the mast from the guy wires. It will be appreciated that the height of the mast determines the length of the radiating element and thus the center frequency of the system in the embodiment of FIG. 2.

Likewise, it will be appreciated that the retractable mast need not be of the telescoping variety as shown in FIG. 2 and that other masts either temporary or permanent in nature, may be substituted therefor. For example, the mast might be raised and lowered as in the manner of the periscope and, in fact, the periscope itself might be employed in a submarine application. Otherwise, a conventional screw type or a scissors type means might be employed to hoist the radiating elements.

While sturdy examples are cited above, it is appreciated that the guy wires, which are essential to this invention, reduce the strength requirement of the mast and that relatively light duty masts might be employed if desired. Thus in a rescue operation where communication equipment is to be air dropped to a remote point to enable radio contact, light weight sections of hollow aluminum tubing adapted for interconnection, as in the case of stacked tent pole sections, would be entirely satisfactory as the antenna mast. Indeed, light weight

rigid coaxial trasmission line might be employed as the mast in the antenna of this invention.

In operational analysis, the antenna of this invention may be considered as a monocone antenna, that is, the selectively disposed guy wires approximate a solid conical surface. As mentioned above, this conical structure has been slightly truncated and the feed point is at the point of truncation. A coaxial type of feed is employed which runs up the center of the conical structure and the outer conductor of the coaxial transmission line within the conical structure serves not only to contain the wave energy within the transmission line but also as a part of the antenna itself.

Thus the center conductor of the transmission line which connects to the conical surface, in effect, fans out and folds back on the transmission line as the radiating surface. It will be appreciated, that the field within the center conductor and the outer conductor of the coaxial line is continued between the conical surface and the outer conductor of the coaxial transmission line. The coaxial line has, of course, a selected impedance, for example 50 ohms, and the impedance at the base of the conical surface is, of course, generally different and is determined by taper of cone, medium, nearby objects, etc. By reason of the uniform flare of the conical surface, this invention has an inherent impedance transformer action which affords a good impedance match between 50 ohms and the impedance of the base of the conical surface. A better and nonfrequency sensitive impedance match is obtained by an exponential taper or flare and this may be provided by the use of plastic spacers, guy wire tires, or the like, not shown in the drawings, which serve to control the circumference and thus the taper of the conical surface at selected interval along the axis thereof.

The open air impedance of a broadband antenna is affected by objects in the environment which are nearby in terms of wavelengths. This phenomena exists for radiating structures generally, and is not unique, of course, to the monocone antenna of this invention. Buildings, other ships and cranes are examples of structures which can exert various degrees of adverse influence on an antenna. Relative motion between an antenna and parasitic structures such as other antennas on a ship usually alters the influence. This is particularly true when the subject antenna operates in the 2 to 6 megacycles frequency band and wavelengths up to 500 feet are involved.

FIG. 3, is a graphical presentation of measured VSWR for a prior art sleeve antenna without an impedance matching transformer (dashed curve A) and for the monocone antenna of this invention (solid curve B). The sleeve antenna represented by Curve A utilized the smoke stack of a ship as the sleeve, and an inclined upper radiator such as shown in FIG. 1 while the antenna represented by Curve B utilized the foremast and four guy wires substantially as shown in FIG. 1.

In each case, the VSWR was measured with respect to 50 ohms, which was the feedpoint or transmission line impedance, and was determined over a 3 to 1 bandwidth (2–6 mc.). It will be noted that in the case of the prior art antenna (dashed Curve A) the VSWR is exceptionally high, for example, at 2 mc., the VSWR was greater than 25.1 at 4 mc., the VSWR was 7.0 and at 6 mc. the VSWR was 6.0. Only in the vicinity of 3 mc. and 5 mc. did the VSWR drop into the tolerable range. On the other hand, the antenna of this invention had a VSWR characteristic (solid curve B) which remained in the tolerable area over substantially the entire 2–6 mc. range. It will be seen from this comparison that the sleeve antenna would be entirely unsatisfactory in those applications having a maximum tolerable VSWR requirement of about 3:1 without the inclusion of an impedance matching transformer.

FIG. 4, is a graphical presentation of a typical azi-

muthal radiation pattern for the installation depicted in FIG. 1, using the foremast of the ship and 4 guy wires as the radiating elements. It will be noted that the antenna is omnidirectional and is substantially uniform in azimuth with the exception of one area where a slight distortion is apparent. This distortion is attributed to the proximity of the ship's bridge structure. In the ideal theoretical condition, that is, in absence of such nearby obstacles, it will be seen that the radiation pattern in the azimuth consideration would be completely uniform and omnidirectional.

Another advantage of the several disclosed embodiments of the invention which has not been particularly pointed out heretofore is to be found in the lightning protection provided by the mast which extends above the radiating elements and is grounded. It will be appreciated by those experienced in the art that a grounded mast, in itself, greatly simplifies antenna structural design problems and is desirable irrespective of the attendant lightning protection it affords.

While the several embodiments of the present invention disclosed herein are especially suitable for use above 2 mc., it is understood that these disclosed embodiments and other embodiments not specifically disclosed herein but within the purview of this disclosure are also useful at lower frequencies. Thus the device of the present invention is adaptable to larger installations such as atop a mountain where the radiating elements might be substantially longer than in the specifically disclosed embodiments.

Furthermore, it is understood that the antenna of this invention is extremely broadband and that the 3:1 bandwidth illustrated in FIG. 3 is not indicative of the actual useful bandwidth.

Finally it is understood that this invention is to be limited only by the scope of the claims appended hereto.

What is claimed is:

1. An antenna suitable for radiation over a broad band of frequencies and having a selected ground plane, comprising an electrically conductive elongated section disposed in substantially perpendicular relation with respect to said ground plane, said elongated section being electrically connected in common with said ground plane; at least two electrical conductors mechanically connected to said ground plant and to said elongated section to form a tapered cross section approximating a triangle of any two of said electrical conductors with said ground plane, said elongated section dividing the angle at the apex of said triangle; means for electrically isolating the center section of each of said electrical conductors from said

ground plane, said center section having a length proportional to the wavelength at a center frequency within said band of frequencies; means for electrically connecting each of said center sections of said electrical conductors in common, the last said means being electrically connected to each of said center sections at the end closest to said apex; said elongated section including a transmission line for the transmission of electrical wave energy to said antenna, and means for applying said electrical wave energy from said transmission line to said means electrically connecting each of said center sections of said electrical conductors in common such that wave energy to be radiated is distributed to said center sections in substantially equal proportions via the ends thereof closest to said apex.

2. A broadband antenna as defined in claim 1 wherein said transmission line is of the coaxial variety having a center conductor and an outer conductor.

3. A broadband antenna as defined in claim 2 where said center conductor is electrically connected to said means electrically connecting each said electrical conductors in common.

4. A broadband antenna as defined in claim 3 wherein said ground plane is the deck of a ship and said electrically conductive elongated section is a mast section thereon.

5. A broadband antennna as defined in claim 3 wherein said electrically conductive elongated section is a collapsible mast section which may be elevated as desired.

6. A broadband antenna as defined in claim 3 wherein said electrically conductive elongated section is a plurality of mast sections disposed to have a common longitudinal axis.

7. A broadband antenna as defined in claim 5 wherein each of said electrical conductors include reel means for altering the length of said electrical conductors during the elevation of said mast section.

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