March 8, 1949. A. S. MEIER 2,463,547

BROAD BAND ANTENNA

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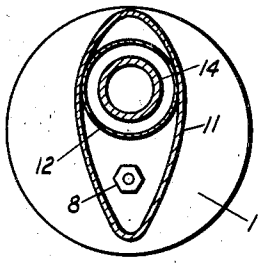

FIG. 2

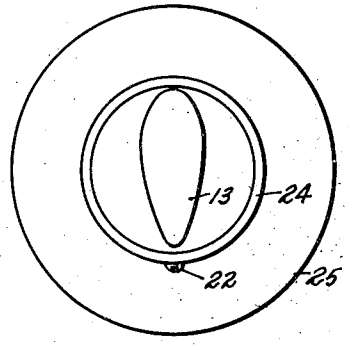

FIG. 6

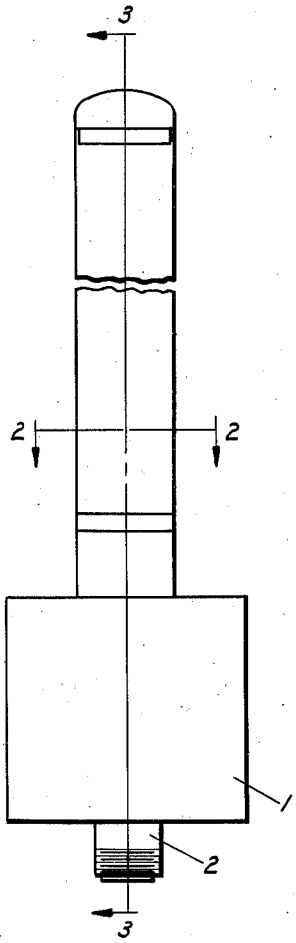

FIG. 1

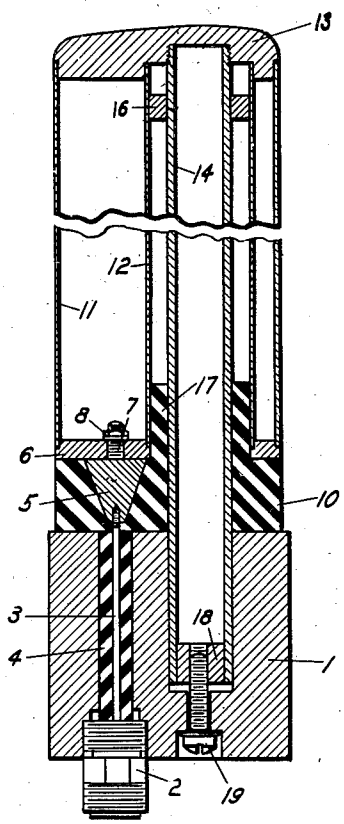

FIG. 3

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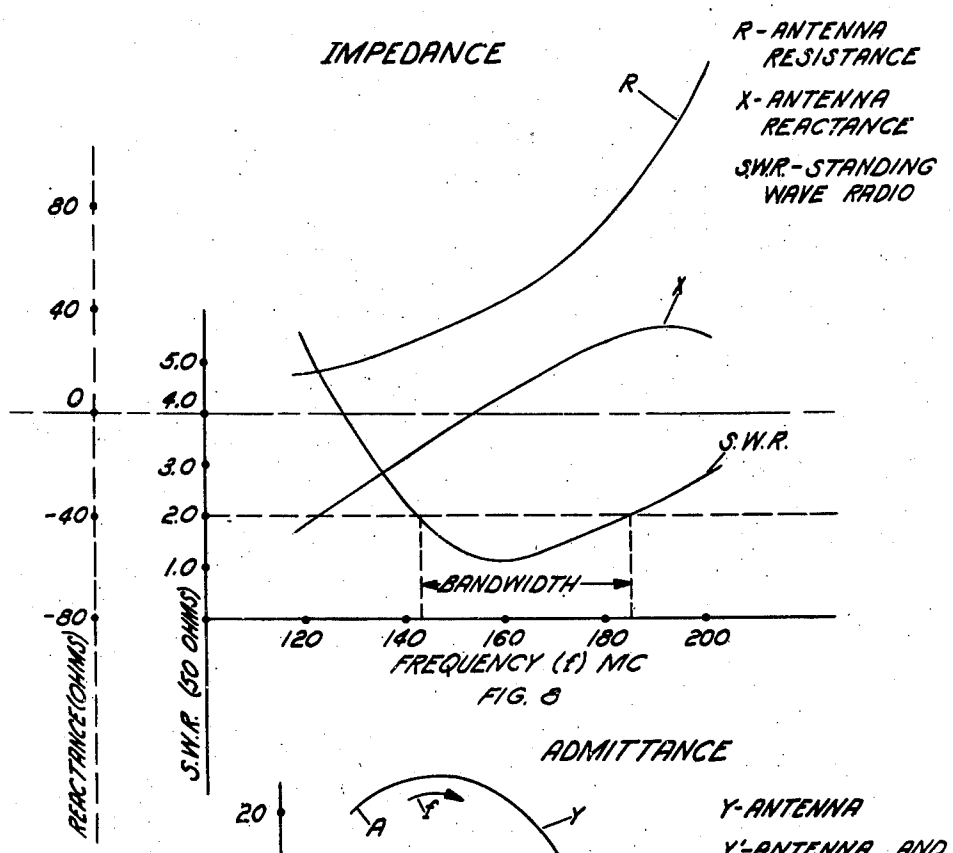

FIG. 8

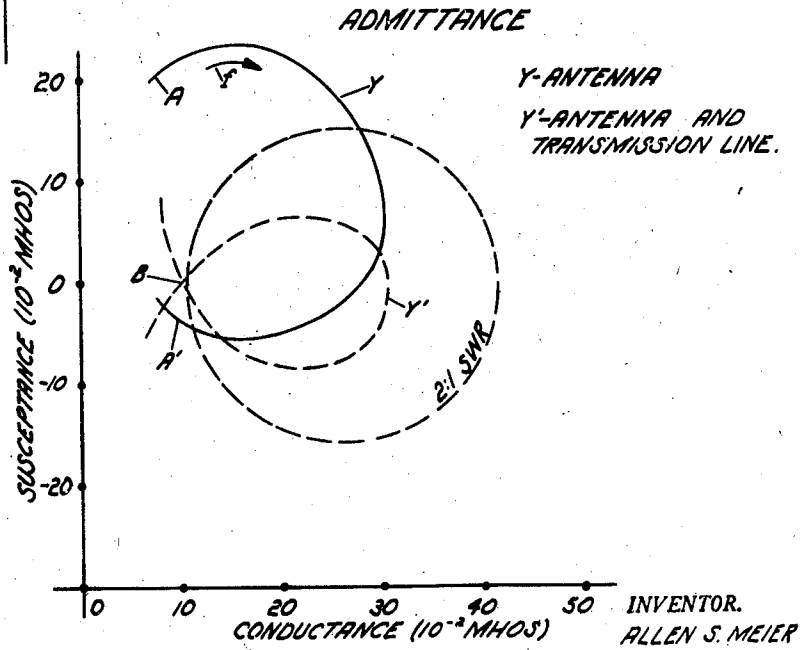

FIG. 9

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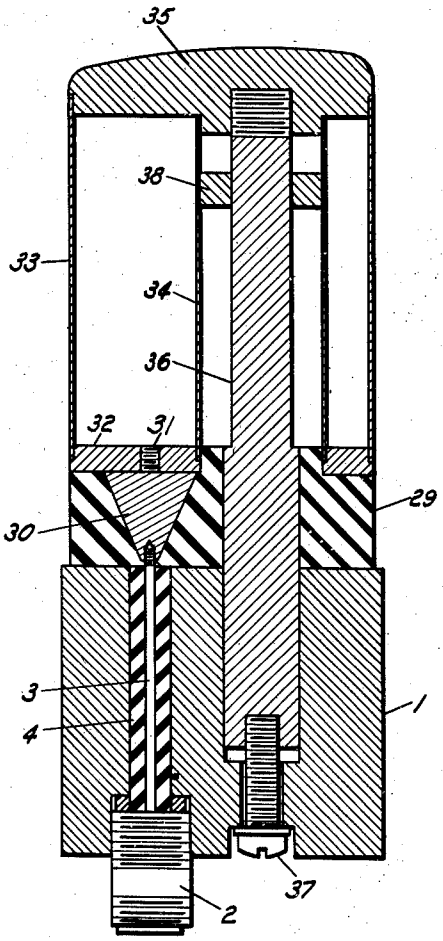

FIG. 7

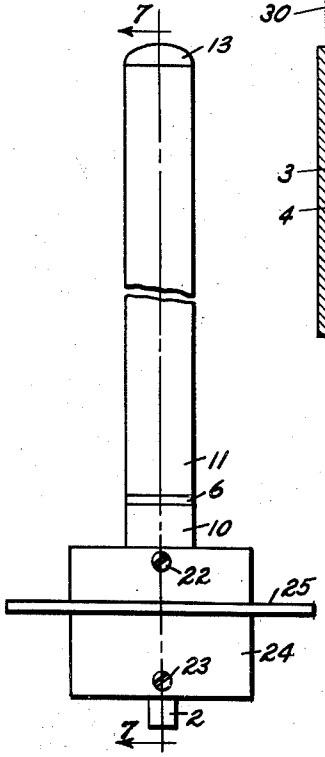

FIG. 5

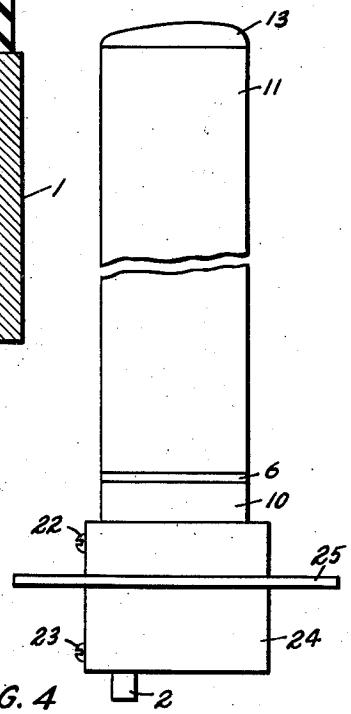

FIG. 4

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UNITED STATES PATENT OFFICE

2,463,547

BROAD BAND ANTENNA

Allen S. Meier, Bloomfield, Conn.

Application January 23, 1945, Serial No. 574,160

5 Claims. (Cl. 250—33)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to antennas and more particularly to a broad band stub antenna.

Broad band antennas that have been produced heretofore have been hollow metal bodies of large lateral dimensions that make the antennas aerodynamically objectionable.

The objects of the present invention comprise the provision of an improved antenna wherein a short circuited transmission line is used as a matching device; a compact, streamlined stub antenna that is adapted for wide band transmission and reception at very high frequencies; and that consists of readily assemblable parts that remain in their proper relation for providing optimum functional results during the life of the antenna.

With the above and other objects in view that will be apparent to those who are informed in the field of antennas from the following description, illustrative embodiments of the present invention are shown in the accompanying drawings, wherein:

Fig. 1 is a front elevation with the blade foreshortened of an antenna that embodies the present invention;

Fig. 2 is a section taken along the line 2—2 of Fig. 1;

Fig. 3 is an axial section taken along the line 3—3 of Fig. 1;

Fig. 4 is a side elevation with the blade foreshortened of a modified form of antenna;

Fig. 5 is a front elevation of the antenna that is shown in Fig. 4;

Fig. 6 is a top plan view of the antenna that is shown in Fig. 4;

Fig. 7 is an axial sectional view taken along the line 7—7 of Fig. 5;

Fig. 8 is a graphical impedance presentation of an experimental antenna that embodies the present invention; and

Fig. 9 is a graphical admittance presentation of the antenna from which the curves that are shown in Fig. 8 were obtained.

The antenna that is shown in Figs. 1–3, inclusive, of the accompanying drawings, comprises a preferably cast aluminum base 1 that preferably provides a mount for the antenna assembly when slipped thru and secured in a collar, not shown, that is installed in the side of a plane fuselage or the like.

Electrical connections for the antenna are provided in any suitable manner, as by a coaxial cable connector or fitting 2 or the like, that threads into the base 1 of the antenna. The outer conductor of the fitting 2 is grounded thru the base 1 to the skin of a ship upon which the antenna is mounted. The inner conductor of the fitting 2 continues as a rod 3 that extends axially of the base 1 and that is insulated therefrom in a suitable manner, as by a cylindrical polystyrene tube 4 or the like, that is interposed between the base 1 and the rod 3.

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The end of the rod 3 that is remote from the fitting 2, makes electrical connection in any desired manner, as thru a conical adapter connector 5 and a plate 6 or the like, to an air foil 11 and an outer conductor element 12 of the antenna, as shown. The conical connector 5 is used at the antenna feed point to reduce the discontinuity of the high frequency connector that has been used in the past for a comparable purpose. The connector 5 preferably receives the threaded end of the rod 3 in its apex and carries a bolt 7 projecting from centrally of its base to pass thru an aperture in the plate 6 and to be secured thereto by suitable means such as by a nut 8 or the like. A dielectric 10 is interposed between the base 1 of the antenna and the plate 6 thereof, as shown.

The outer conductor of the antenna comprises collectively a hollow radiator or air foil 11 that is electrically continuous with an outer element 12 of a coaxial shunt transmission line part of the antenna. The air foil 11 preferably is of streamlined section as shown in Fig. 2 to minimize the wind resistance of the antenna and is seated firmly upon the plate 6, as by having its lower edge seated in a rabbetted groove that extends along the peripheral upper edge thereof, or the like. The coaxial line outer element 12 extends longitudinally of the antenna and also is mounted firmly therein with respect to the plate 6 as by having its lower edge seated in a rabbetted groove that extends along the periphery of an aperture therein as shown, or the like.

The air foil 11 and the coaxial line outer element 12 have their upper ends maintained in firmly predetermined relation with respect to each other as by means of a cap 13 or the like. In the assembly shown, the upper end of the air foil 11 is disposed within a rabbetted groove that extends along the peripheral edge of the cap 13 adjacent the lower face thereof. The outer face of the cap 13 is preferably streamlined as shown. The upper end of the coaxial line outer element 12 is disposed against the radially outer face of

a substantially circular depression in the lower face of the cap 13. The outer element 12 is substantially coaxial with a hollow cylindrical coaxial line inner element 14. The coaxial line inner element 14 preferably serves the dual purpose of acting as the inner element of a coaxial line and as a tie member for insuring the permanence of the antenna assembly.

The coaxial line inner element 14 preferably has its upper end secured to the cap 13 in any desired manner, as by threading into the lower face of the cap 13 welded thereto, or the like. A shorting plug 16 that is disposed between the inner conductor 14 and the outer conductor 12 determines the effectual electrical length of the coaxial line, and is preferably permanently secured therein. The relative disposition of the coaxial line inner element 14 with respect to the coaxial line outer element 12 at the lower end thereof is preferably insured under vibrational stresses by a collar portion 17 that continues axially upwardly of the antenna therebetween from the dielectric 10. Suitable means, such as a plug 18 or the like, that is secured to the coaxial line inner element 14 in any suitable manner, as by being sweated, press-fit, or welded into the lower end thereof, is provided for the threaded seating therein of an assembly screw 19 that serves to draw the coaxial line inner element 14 axially downwardly of the antenna and thereby uses the inner element 14 of the shunt transmission line matching section of the antenna to secure the upper parts of the antenna firmly together.

The broad band antenna that is so constructed provides an improved stub antenna that has broad band characteristics imparted thereto by the presence therein of a coaxial shunt transmission line that comprises the inner conductor 14 that is coaxial with the outer conductor 12 of the line and that is adjustably terminated by the positioning of the shorting plug 16. In the assembly described, the coaxial line inner conductor 14 is grounded electrically at its lower end thru the base 1 to the skin of the ship upon which the antenna is mounted and is connected electrically at its upper end thru the shorting plug 16 to the upper end of the coaxial line outer conductor 12 that is insulated electrically from the skin of the ship.

A series resonant antenna has a negative susceptance slope within the region of resonance and hence a shunt reactance may be used to advantage in securing optimum band width qualities of the basic antenna. The shunt element that is most useful at high frequencies is a quarter wavelength short-circuited transmission line in shunt relation with the antenna, the susceptance having a positive slope of susceptance in the region of resonance.

In this method of matching, the increase in band width is derived from the lower end of the frequency band, so that for a given band a shorter antenna structure is required. A shunt matched antenna has been found to be adequate if only 83.4% as long as an unmatched antenna. The basic forms of substantially all metallic antennas, in which the properties of a quarter wave length transmission line are used to insulate electrically the antenna from ground, have structural details which lend themselves to be broad banded by the shunt method that is described herein.

A slightly modified form of the antenna is shown in Fig. 7 of the accompanying drawings. In this construction a dielectric 29, in which a cone 30 connection with the central terminal 3

of the connector 2 is disposed, is interposed between the antenna base 1 and a plate 32. A screw 31 that projects from centrally of the base of the cone 30, threads directly into the plate 32. The plate 32 provides a lower rest for the antenna air foil 33 and the outer conductor 34 of a coaxial line part of the antenna. A cap 35 has the upper end of the inner conductor 36 threaded thereinto and secures the assembly together when the connecting screw is tightened against a shoulder in a bore in the antenna base 1 as shown. A shorting plug 38 is welded in place and determines the electrical length of the antenna. The antenna that is shown in Fig. 7 functions in substantially the same manner as that shown in Fig. 3 functions.

Fig. 8 of the drawings discloses three curves plotted from data gathered from experimental antennas that embody the present invention. The curves are plotted upon coordinates of frequencies with standing wave ratios, and frequencies with reactance. The curve R is that of the antenna resistance; the curve X is that of the antenna reactance; and the curve SWR is that of the standing wave ratio of the antenna at a 50 ohm level measured without the shunt transmission line.

Fig. 9 of the drawings is the admittance curve of the same antenna wherein the antenna's conductance is plotted against its susceptance. The Y full line curve is that of the antenna that provided the data shown in Fig. 8 and the Y' dash curve is that of the antenna with the short circuited transmission line which produces optimum bandwidth.

The optimum bandwidth is secured by the cancellation of the antenna susceptance over a maximum band of frequencies without exceeding the prescribed standing wave ratio limits, as shown on the curve in Fig. 9. The curve Y in Fig. 9 is compressed to the curve Y' upon the addition of the transmission line to the antenna and at which curve Y' the antenna has its maximum bandwidth. For conditions of maximum bandwidth the susceptance that is required to transform the ends A—A' on the curve Y are drawn together to intercept at the point B on the curve Y' for the determination of the correct electrical length and the characteristic impedance of the matching transmission line.

It is to be understood that the antenna constructions that have been disclosed herein have been submitted for the purposes of illustrating and describing suitable embodiments of the present invention and that satisfactorily functioning modifications, changes and substitutions may be made in the parts thereof and in their assembly without departing from the present invention as defined by the appended claims.

What I claim is:

1. A broad band radio stub antenna, comprising in combination an inner conductor, an outer conductor coaxial with said inner conductor to provide a coaxial shunt transmission line, an electrically conducting base supporting said inner and outer conductors, a dielectric insulating one end of said inner conductor from the corresponding end of said outer conductor and maintaining a predetermined spatial relation therebetween and insulating said outer conductor from said electrically conducting base, an electrically conducting cap mounted upon and short-circuiting the ends of said inner and outer conductors that are remote from said base and secured to said inner conductor, a supporting plate disposed

upon said dielectric and against which the end of said outer conductor that is remote from said cap rests and makes electrical connection therewith, an airfoil disposed transversely outwardly of both said inner and said outer conductors and interposed longitudinally between said cap and said plate, an adapter making electrical connection with and converging away from said plate and insulated electrically from the lower end of said inner conductor and from said base, a coaxial fitting having an outer member in electrical connection with said base and insulated from an inner member in electrical connection with said adapter, and connector means for adjustably drawing said inner conductor toward said base and thereby clamping said outer conductor and said airfoil between said cap and said plate.

2. A broad band radio stub antenna, comprising, in combination, an inner conductor, an outer conductor coaxial with said inner conductor to provide a vertical coaxial transmission line, an electrically conducting base supporting the lower ends of said inner and outer conductors, a dielectric insulating the lower end of said inner conductor from the lower end of said outer conductor and maintaining a predetermined spatial relation therebetween and insulating said outer conductor from said base, an electrically conducting cap mounted upon and short-circuiting the upper ends of said inner and outer conductor, a supporting plate disposed upon said dielectric and against which the lower end of said outer conductor rests and makes electrical connection therewith, a hollow airfoil surrounding said outer conductor and interposed longitudinally between said cap and said plate, an adapter making electrical connection with and converging away from said plate and insulated electrically from the lower end of said inner conductor and from said base, an inner conducting rod connected to said adapter, a coaxial fitting having an outer member in electrical connection with said base and insulated from said conducting rod, and provided with internal means for connection to an external coaxial cable.

3. A broad band radio stub antenna, comprising in combination an inner conductor, an outer conductor coaxial with said inner conductor to provide a coaxial transmission line, an electrically conducting base supporting the lower ends of said inner and outer conductors, a dielectric insulating the lower end of said inner conductor from the lower end of said outer conductor and

maintaining a predetermined spatial relation therebetween and insulating said outer conductor from said base, an electrically conducting cap mounted upon and short-circuiting the upper ends of said inner and outer conductors, a supporting plate disposed upon said dielectric and against which the lower end of said outer conductor rests and makes electrical connection therewith, and a hollow airfoil surrounding said outer conductor and interposed longitudinally between said cap and said plate.

4. A broad band radio stub antenna, comprising in combination, a hollow airfoil, an inner conductor, an outer conductor coaxial with said inner conductor to provide a coaxial transmission line in shunt with said airfoil and disposed therein, conducting means supporting and connecting said outer conductor and said airfoil, short-circuiting means on the upper ends of said inner and outer conductors and airfoil, base means for said antenna supporting said inner conductor, and a dielectric supported by said base means and supporting said conducting means, said dielectric having a collar extending upwardly between said inner and outer conductors to space the same.

5. A broad band radio stub antenna, comprising in combination, a hollow airfoil, an inner conductor, an outer conductor coaxial with said inner conductor to provide a coaxial transmission line in shunt with said airfoil and disposed therein, a horizontal conducting plate having grooves into which fit the lower ends of said outer conductor and airfoil, short-circuiting means on the upper ends of said inner and outer conductors and airfoil, base means for said antenna supporting said inner conductor, and a dielectric supported by said base means and supporting said conducting plate, said dielectric having a collar extending upwardly between said inner and outer conductors to space the same.

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