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SCIMITAR ANTENNA

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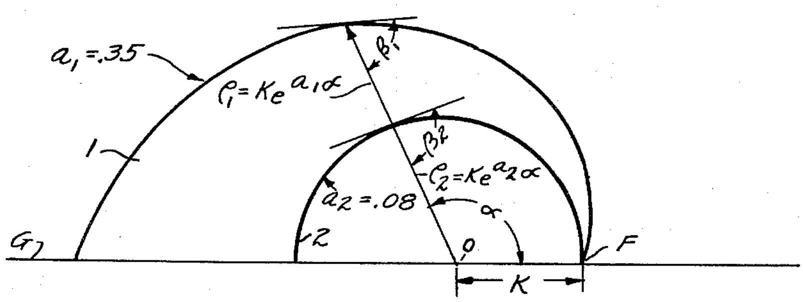

FIG. 1

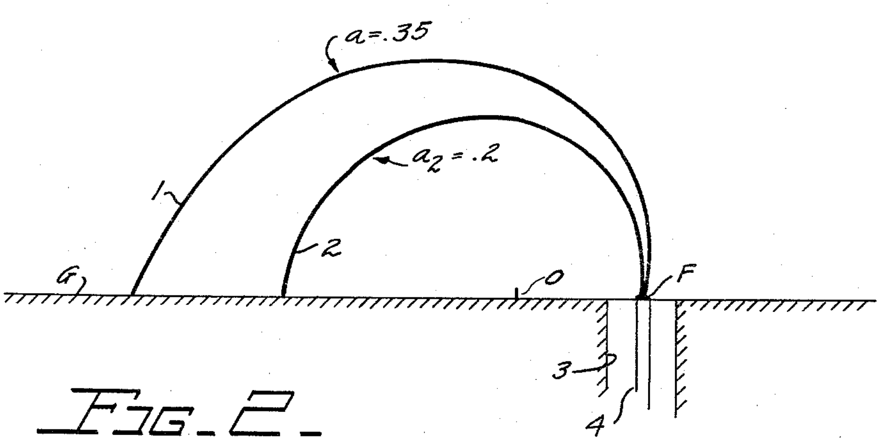

FIG. 2

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FIG. 3

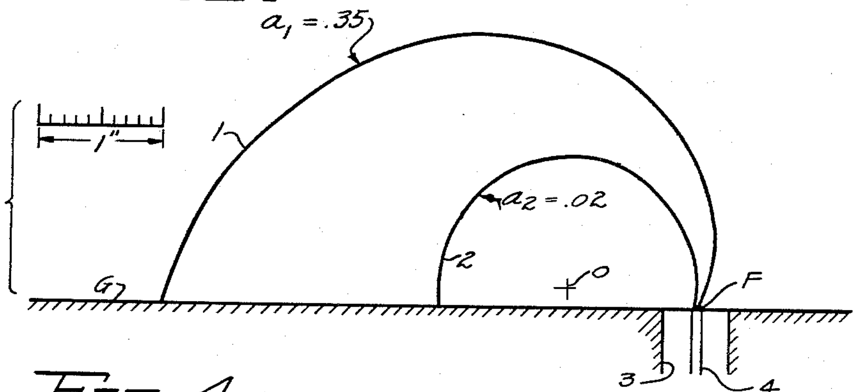
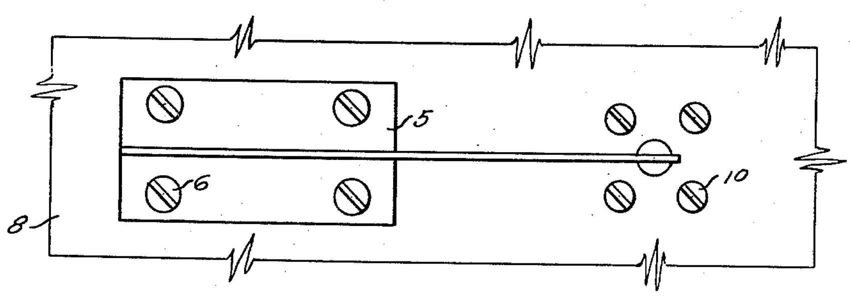


FIG. 4a



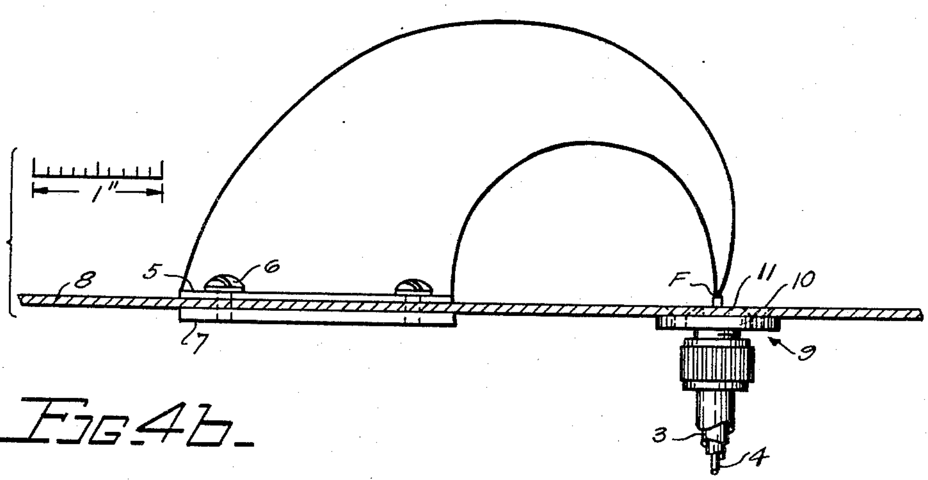


FIG. 4b

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FIG. 3a

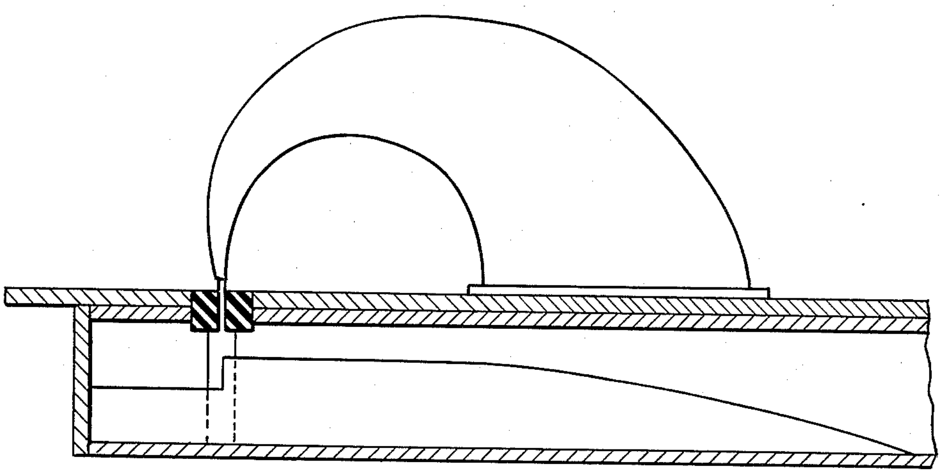
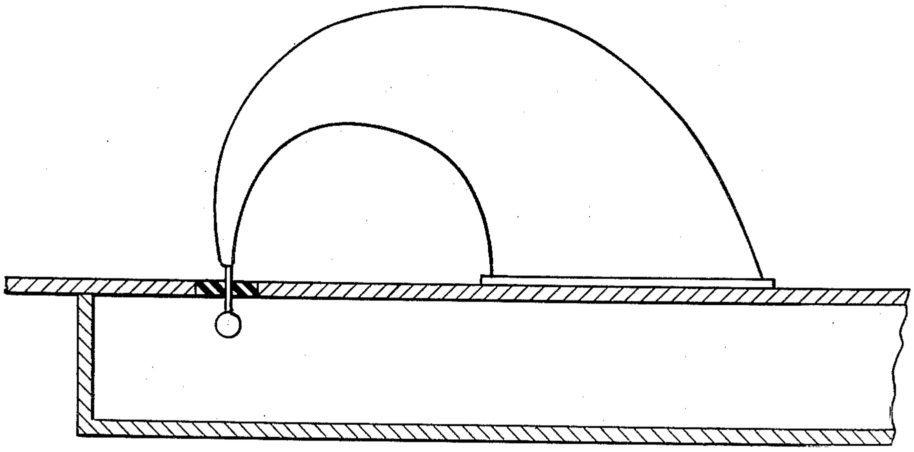


FIG. 3b



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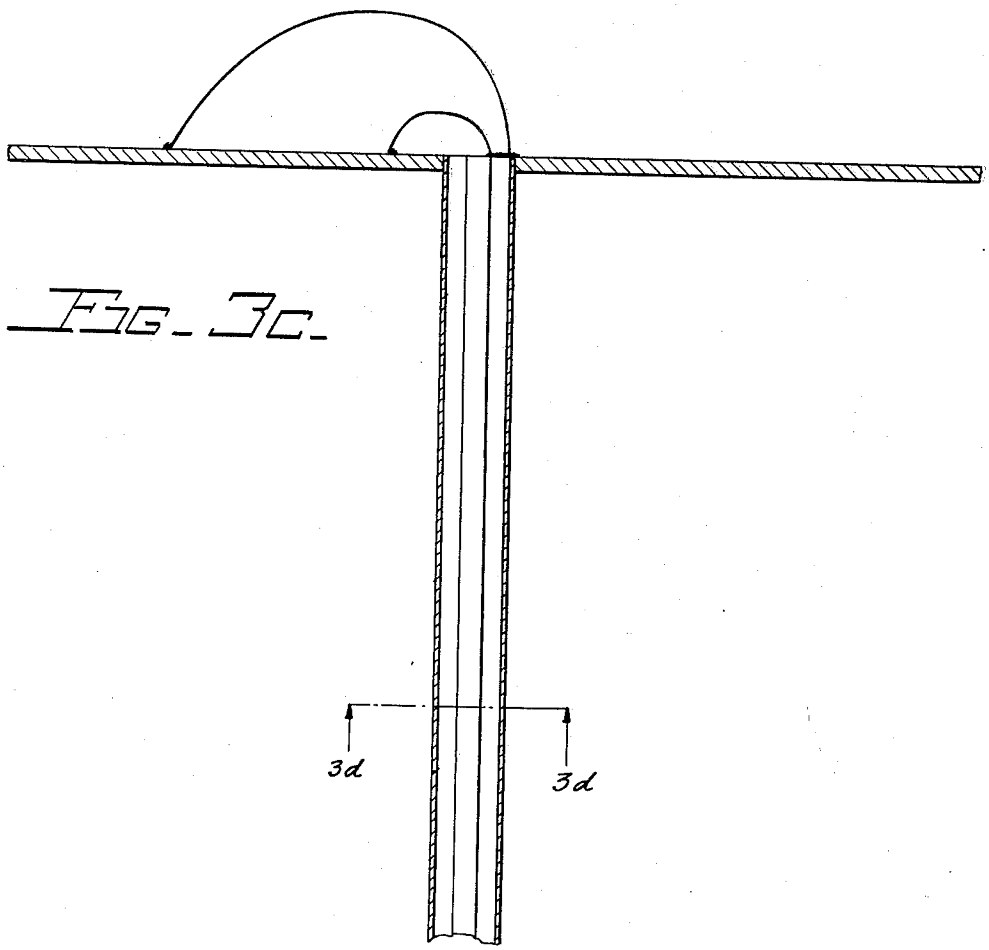

FIG. 3c

FIG. 3d

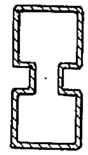

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FIG. 5

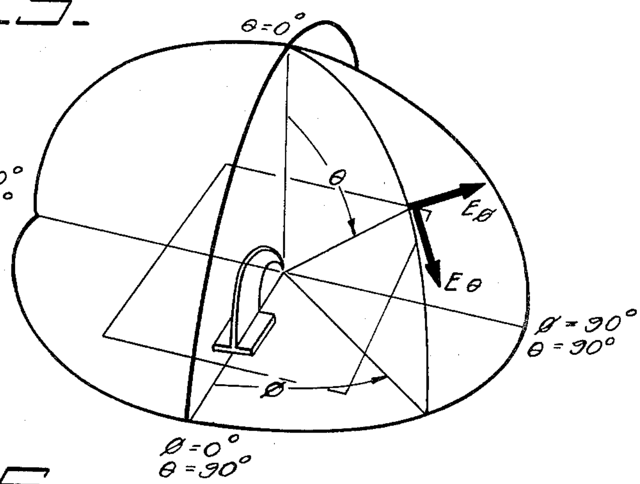
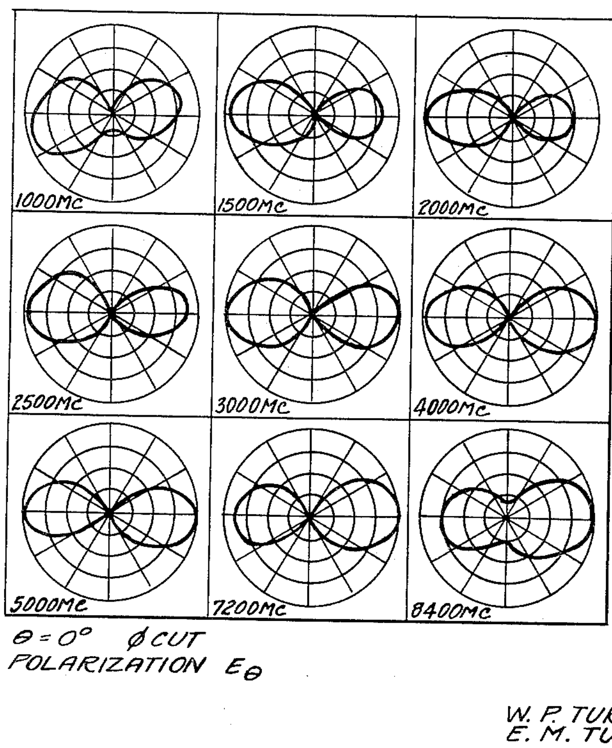


FIG. 6



θ=0° Ø CUT
POLARIZATION Eθ

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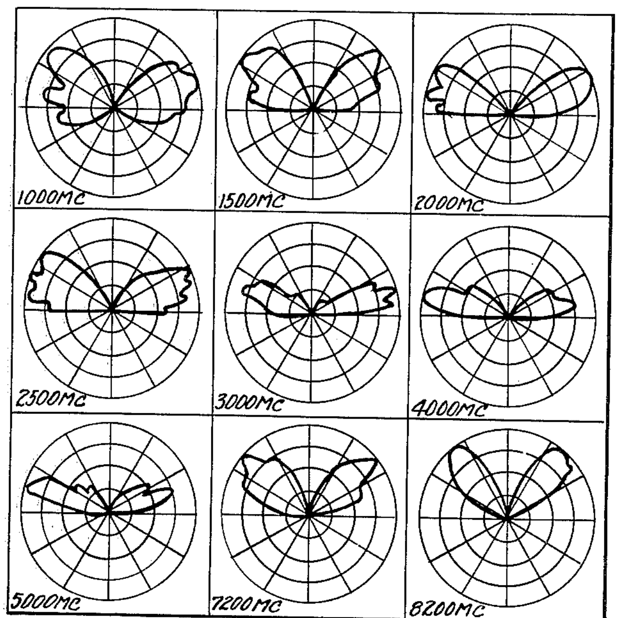
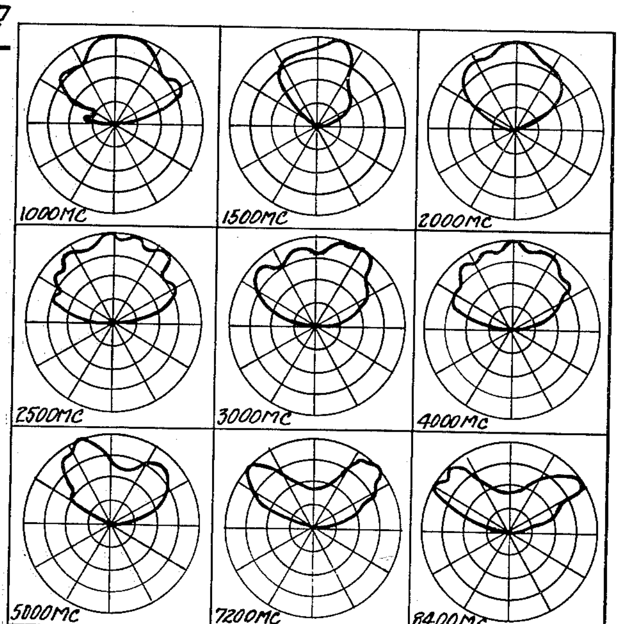
FIG. 7



$\phi = 90°$ θ CUT
POLARIZATION E_θ

FIG. 8



$\phi = 90°$ θ CUT
POLARIZATION E_ϕ

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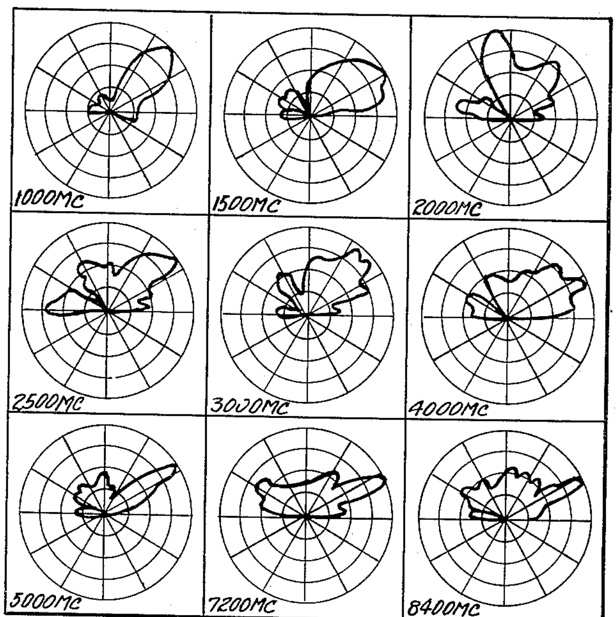
FIG. 9



$\phi = 0^\circ$ θ CUT
POLARIZATION E_θ

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FIG. 10

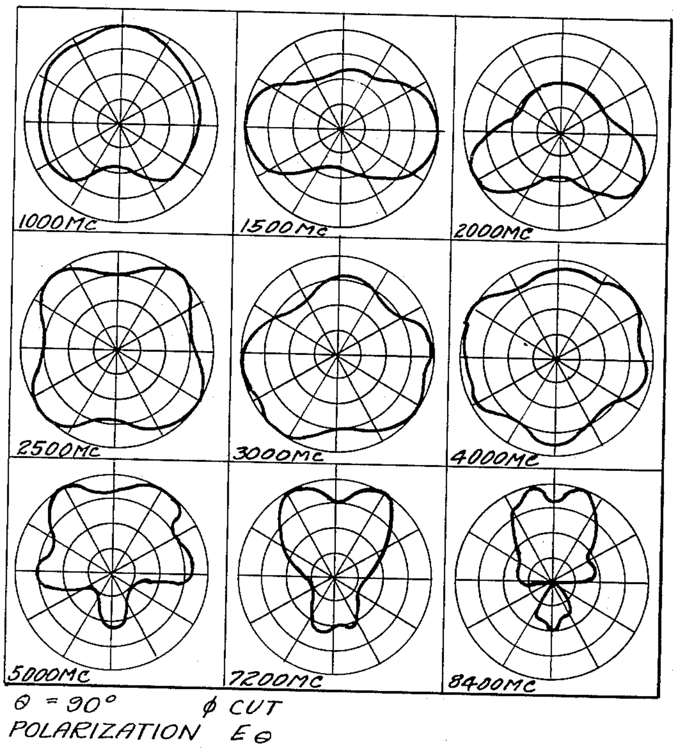
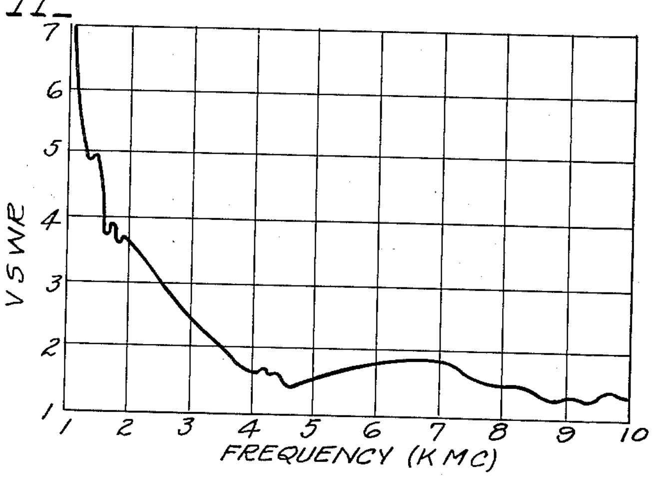


FIG. 11



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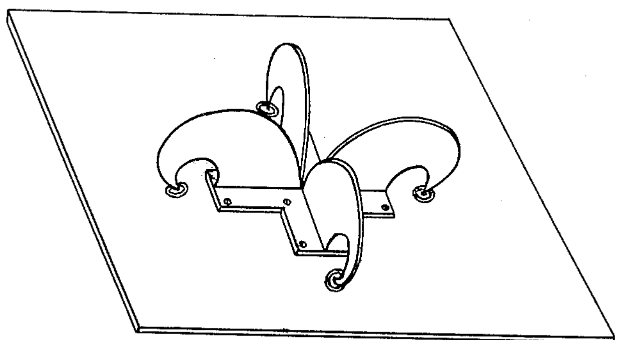

FIG. 12a.

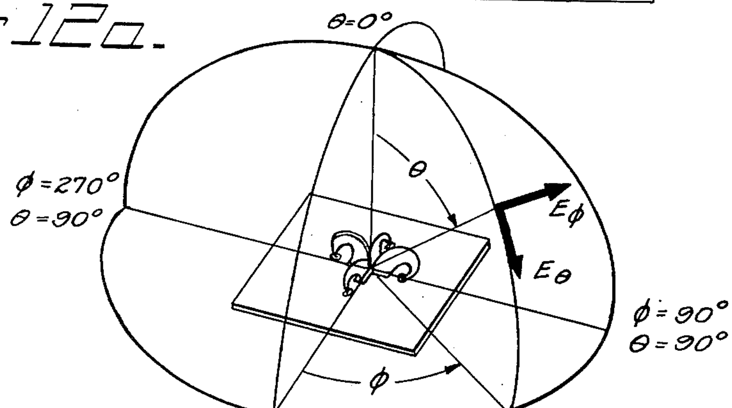

FIG. 12b.

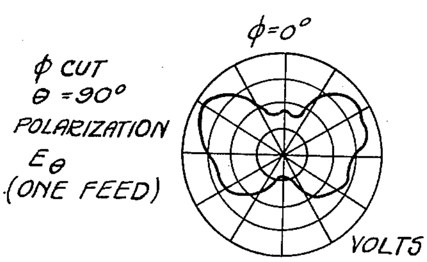

FIG. 12c.

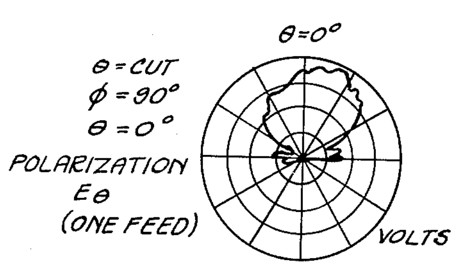

FIG. 12d.

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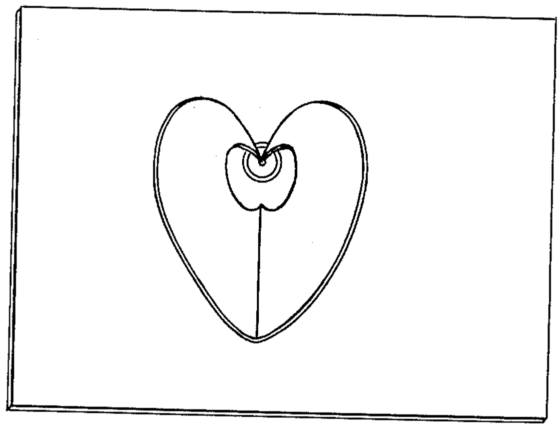

FIG. 13a

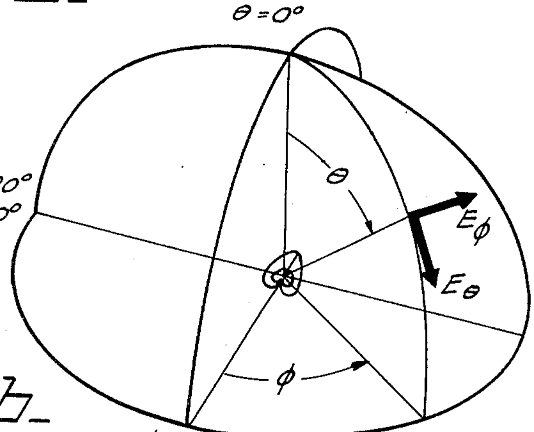

FIG. 13b

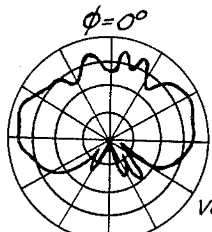

FIG. 13c

FIG. 13d

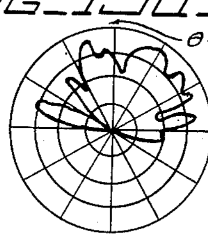

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FIG. 14a

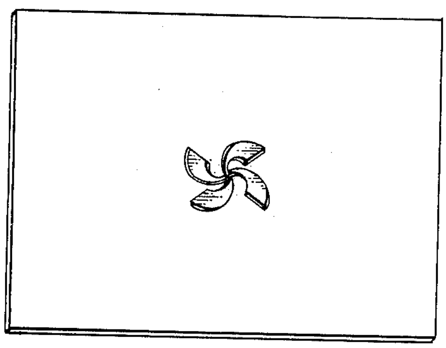


FIG. 14b

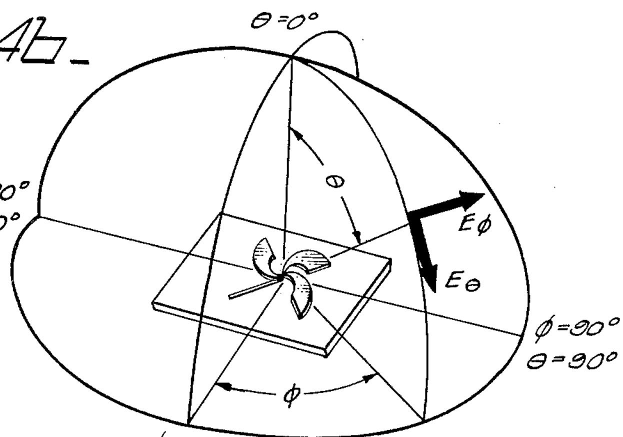
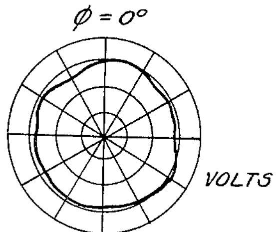
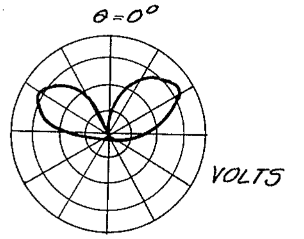


FIG. 14c



φ CUT
θ = 70°
POLARIZATION Eθ

FIG. 14d



θ CUT
φ = 0°
POLARIZATION Eθ

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FIG. 15a

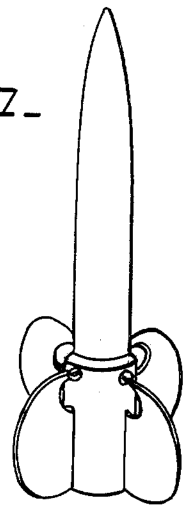


FIG. 15b

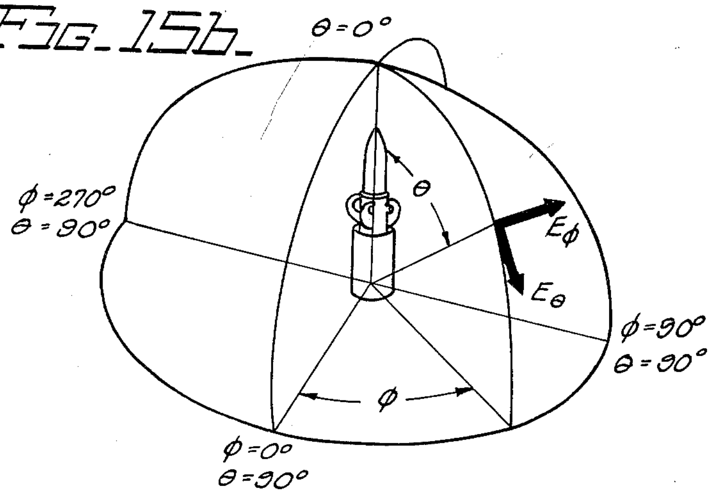


FIG. 15c

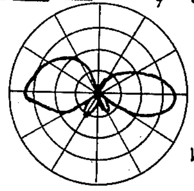
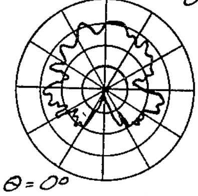


FIG. 15d



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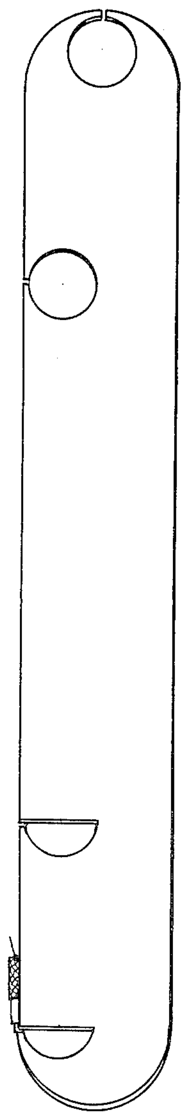

Fig. 16.

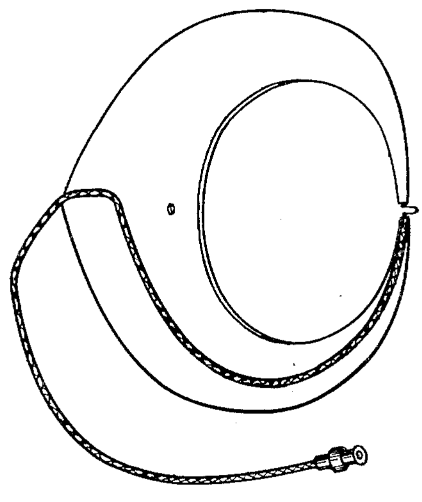

Fig. 17a.

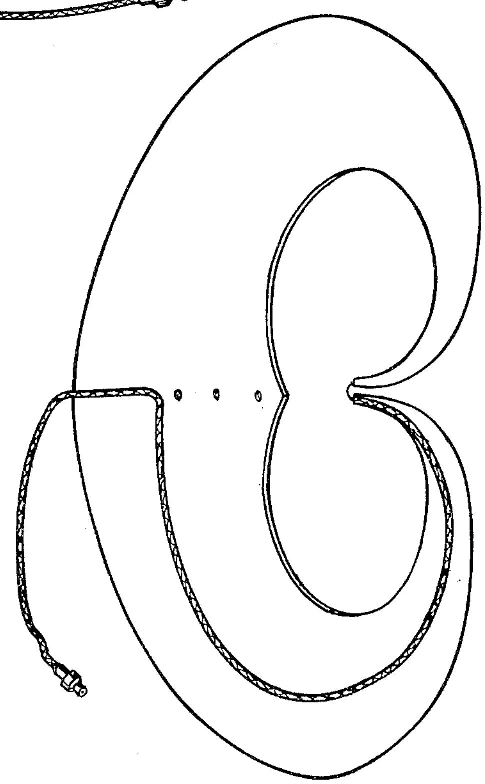

Fig. 17b.

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FIG. 18a

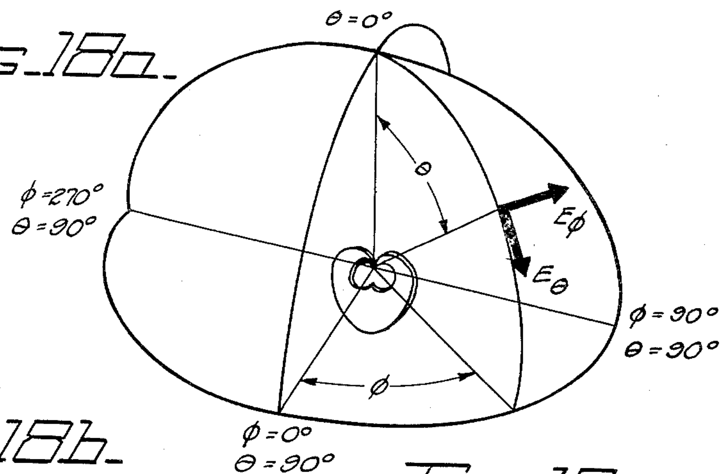
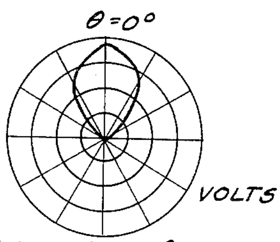
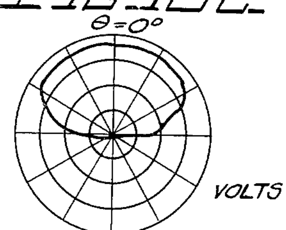


FIG. 18b



θ CUT, φ=90°
θ=0°
POLARIZATION Eθ
NO GROUND PLANE

FIG. 18c



θ CUT, φ=0°
θ=0°
POLARIZATION = Eφ
NO GROUND PLANE

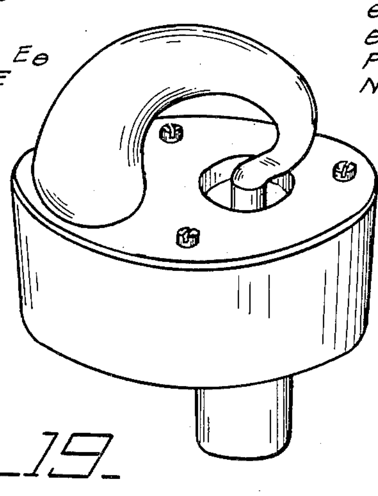


FIG. 19

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United States Patent Office

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Patented Dec. 26, 1961

3,015,101
SCIMITAR ANTENNA

Edwin M. Turner and William P. Turner, Dayton, Ohio, assignors to the United States of America as represented by the Secretary of the Air Force

Filed Oct. 31, 1958, Ser. No. 771,168
5 Claims. (Cl. 343—848)
(Granted under Title 35, U.S. Code (1952), sec. 266)

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

This invention relates to antennas operable in the 30 to 30,000 mc./s. frequency range and is particularly concerned with the provision of an antenna for this frequency range having the desirable electrical properties of pattern stability, impedance stability and high efficiency over a bandwidth of the order of 10 to 1, and having physical properties such as ruggedness, simplicity, ease of mounting and low drag that make it particularly suited to use on aircraft.

The antenna consists of one or more elements each essentially a coplanar equiangular stub antenna with a folded over shorted base, the general configuration being that of a scimitar blade having its broad end electrically and mechanically attached to the ground plane, which may be the surface of the aircraft, and its point coupled to the feed line.

A more detailed description of the antenna will be given with reference to the specific embodiments thereof shown in the accompanying drawing in which

FIGS. 1, 2 and 3 show various forms of the antenna with a coaxial feed line,

FIGS. 3*a*, 3*b*, 3*c* and 3*d* show waveguide feeds for an antenna element,

FIGS. 4*a* and 4*b* show plan and elevation views, respectively, of a physical embodiment of the antenna,

FIG. 5 illustrates the coordinate system used in portraying antenna patterns,

FIGS. 6, 7, 8, 9 and 10 show various field patterns of an antenna such as shown in FIGS. 4*a*—4*b* based on the coordinate system of FIG. 5,

FIG. 11 is a graph illustrating the relatively stable impedance of an antenna of the type described,

FIGS. 12*a*, 12*b*, 12*c*, 12*d*, 13*a*, 13*b*, 13*c*, 13*d*, 14*a*, 14*b*, 14*c*, 14*d* and 15*a*, 15*b*, 15*c*, 15*d* show forms of the antenna using more than one scimitar element,

FIG. 16 shows the manner in which the antenna may be incorporated in a flat plate such as an aerodynamic control element,

FIGS. 17*a* and 17*b* show other forms of the antenna using dual elements,

FIGS. 18*a*, 18*b* and 18*c* show the characteristics of antenna 17*a*, and

FIG. 19 is form of the antenna in which the element has a circular cross section.

FIG. 1 shows the general configuration of the antenna element. The outer and inner boundaries of the antenna element, which may be cut from a sheet of suitable conductive material such as copper or brass, silverplated if desired, to increase surface conductivity, follow diverging spiral paths 1 and 2. These start at feed point F and end at a conductive ground plane G to which the broad end of the element is electrically connected. The curves 1 and 2 are logarithmic spirals having their origin at O which, in this case, lies in the ground plane G. The general equation of these curves is

$$\rho = ke^{a\alpha} \qquad (1)$$

where ρ is the distance from origin to curve, α is the direction of ρ measured from the starting point, in this

case the feed point F, e is the natural logarithm base, and k and a are constants which provide the parameters through which various forms of the antenna element may be derived. The constant k is the same for both inner and outer boundaries and determines the overall size of the antenna element. The constant a determines the rate at which the spiral moves outward from the origin O. As a approaches zero, the spiral approaches a circle. In FIG. 1, the values of a for the outer boundary, designated a_1, is 0.35 while that for the inner boundary, designated a_2 is 0.08. A characteristic of the logarithmic spiral is that the angle (β_1 or β_2) between the tangent to any point and the line from that point to the origin is constant for all points on the curve.

The difference between a_1 and a_2 determines the rate of divergence of the outer and inner boundaries of the antenna element. Decreasing the difference causes the rate of divergence to decrease as may be seen by comparing FIG. 2, where $a_2 = .2$, with FIG. 1. Increasing this difference causes the rate of divergence to increase as may be seen by comparing the antenna element of FIG. 3, for which $\alpha_2 = 0.02$, with FIG. 1. FIG. 3 also illustrates the effect of placing the origin for the outer and inner boundaries above the ground plane rather than in the ground plane as in FIGS. 1 and 2. The effect is to increase both the length of the antenna element and its height above the ground plane.

The antenna may be fed by a coaxial transmission line having its outer conductor connected to the surface forming the ground plane and its inner conductor extending through a hole in this surface to the feed point F of the antenna element. This is illustrated in FIGS. 2 and 3 where 3 and 4 are the outer and inner conductors, respectively, of the coaxial line. The antenna element may also be fed from a waveguide as shown in FIGS. 3*a*, 3*b*, 3*c* and 3*d*.

FIGS. 4*a* and 4*b* show a practical embodiment of a scimitar antenna in which the antenna element has the same parameters as that in FIG. 3. The antenna element is shown as having a thickness of 0.0625″ and has a base plate 5 joined to its broad end for convenient attachment, by means of screws 6 and subplate 7, to the metallic aircraft skin 8 which serves as the ground plane. A suitable coaxial line fitting 9 is attached to the under side of skin 8 by screws 10 and serves to connect the outer conductor 3 of the coaxial line to the metallic surface 8. The center conductor 4 of the transmission line extends through a hole 11 in skin 8 for connection, as by soldering, to the feed point F of the antenna element.

The constants a_1, a_2 and k, the position of origin O relative to the ground surface, and the shape of the ground surface are all parameters affecting the electrical characteristics of the antenna. These may be varied experimentally to obtain the characteristics desired. FIGS. 6–10 show field strength patterns, on a voltage basis, extending over a frequency range of 1000 mc./s. to 8400 mc./s. for an antenna having substantially the same parameters as that shown in FIGS. 4*a*–4*b* and using a flat 14″ x 14″ ground plane. These patterns are with respect to the coordinate system shown in FIG. 5, E_θ and E_ϕ being the vertical and horizontal components, respectively, of the electric vector.

FIG. 11 shows the voltage standing wave ratio (VSWR) measured on a transmission line feeding the typical scimitar antenna. These measurements are made over a wide frequency band and show the relatively low value and relatively small variation of the VSWR of the greater portion of the band.

FIG. 12*a* shows an antenna made up of four basic scimitar elements. All or any number of these elements may be fed in order to achieve the desired directivity pattern. FIGS. 12c and 12d show patterns, based on the coordinate system of FIG. 12b, as specified for a single feed.

FIG. 13a shows a "butterfly" antenna arrangement consisting of two scimitar antennas joined at their bases and feed points and making equal angles with the ground plane. FIGS. 13c and 13d show patterns as specified based on the coordinate system of FIG. 13b.

FIG. 14a shows a "cloverleaf" arrangement consisting of four basic scimitar elements equally spaced and equally inclined to the ground plane. All elements are fed from a common point. FIGS. 14c and 14d show patterns as specified based on the coordinate system of FIG. 14b.

FIG. 15a shows the manner in which the stabilizing fins of a missile may be shaped to perform the functions of radio antennas. Each fin constitutes a basic scimitar antenna fed through an opening in the missile body. FIGS. 15c and 15d show patterns as specified for a single antenna element based on the coordinate system of FIG. 15b.

FIG. 16 shows various ways in which antennas of the scimitar type or similar thereto may be incorporated in a thin metallic member which may be, for example, an aerodynamic control element, on a missile or similar device. The method of feeding one of the antennas with a coaxial transmission line is shown. The other elements may be similarly fed.

FIGS. 17a and 17b show two forms of a dual element antenna in which the two scimitar elements lie in the same plane. FIGS. 18b and 18c show patterns as specified for the antenna of FIG. 17a based on the coordinate system of FIG. 18a.

Although it is conventient and in many cases desirable to make the scimitar element from a flat relatively thin piece of metal, it may also be given other than a thin rectangular cross section as shown in FIG. 19 in which the antenna element has a circular cross section.

We claim:

1. An antenna comprising means forming a conductive ground surface and a curved antenna element attached and electrically connected at one end to said ground surface and extending to a feed point situated substantially in the plane of said ground surface, the farther and nearer boundaries of said element relative

to said surface being two diverging co-planar logarithmic spirals starting at said feed point and ending at said surface.

2. An antenna as claimed in claim 1 in which said logarithmic spirals have a common origin.

3. An antenna comprising means forming a conductive ground surface and a curved antenna element attached to and electrically connected at one end to said ground surface and extending to a feed point situated substantially in the plane of said ground surface, said element having a uniform thickness and having farther and nearer boundaries relative to said surface that are diverging logarithmic spirals starting at said feed point and ending at said surface.

4. An antenna comprising means forming a conductive ground surface, a plurality of curved antenna elements each attached to and electrically connected at one end to said ground surface and extending to a common feed point situated substantially in the plane of said ground surface, each of said elements having a uniform thickness and having farther and nearer boundaries relative to said ground surface that are two diverging co-planar logarithmic spirals starting at said feed point and ending at said ground surface, the plane of said spirals being at an acute angle to said ground surface, and a transmission line situated beneath said ground surface and coupled through a hole in said ground surface to said antenna elements at said feed point.

5. Apparatus as claimed in claim 4 in which said elements are of equal size and are equally spaced about said feed point.

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