SLOTTED CONE ANTENNA

Filed Feb. 16, 1966 2 Sheets-Sheet 1

Fig. 1

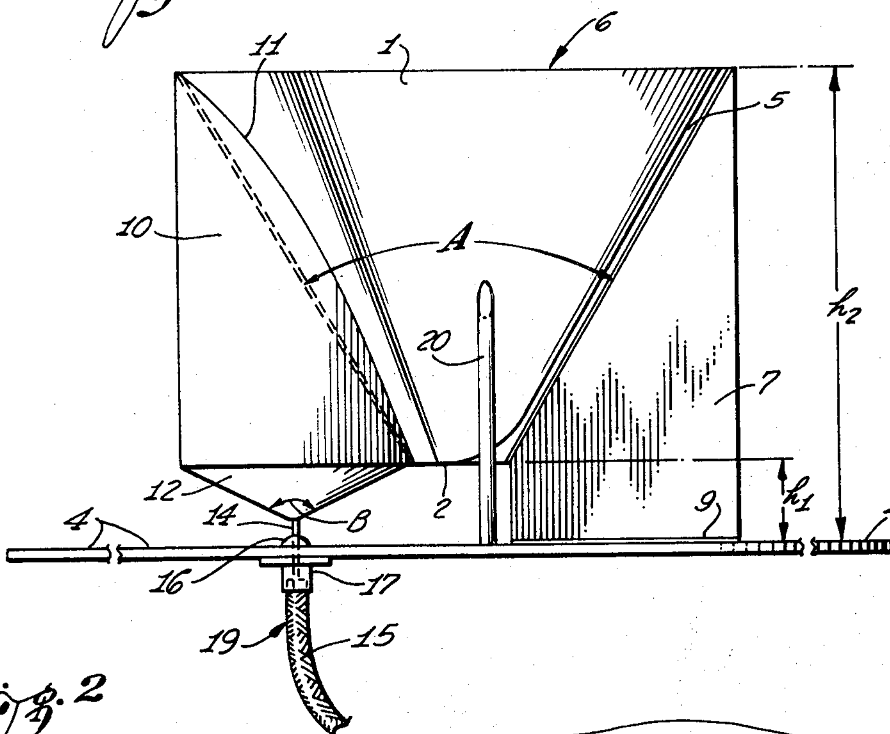
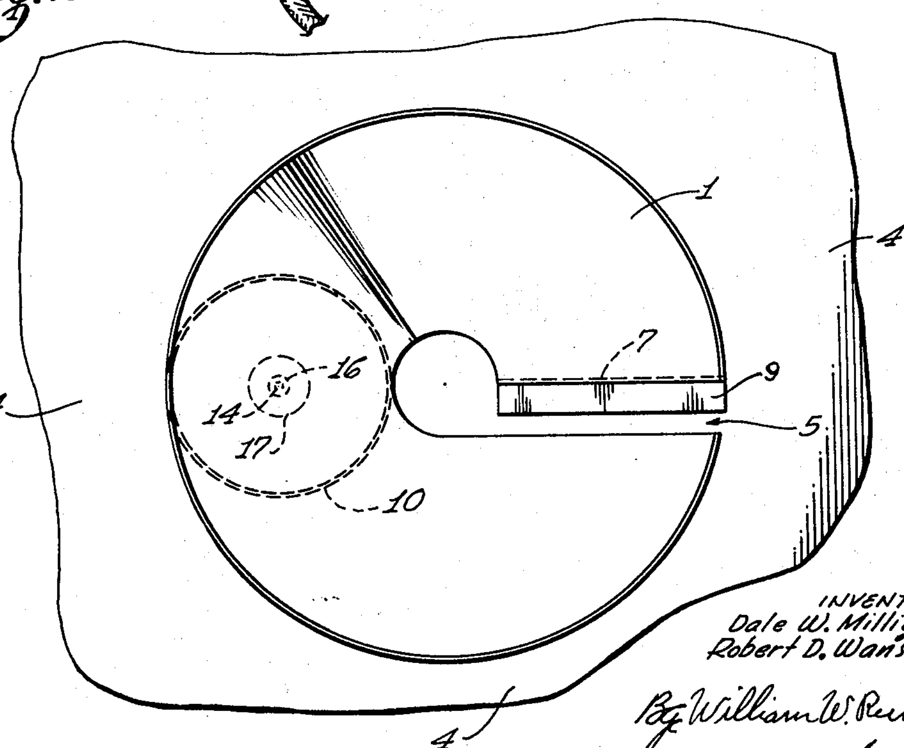


Fig. 2



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Filed Feb. 16, 1966 2 Sheets-Sheet 2

Fig. 3

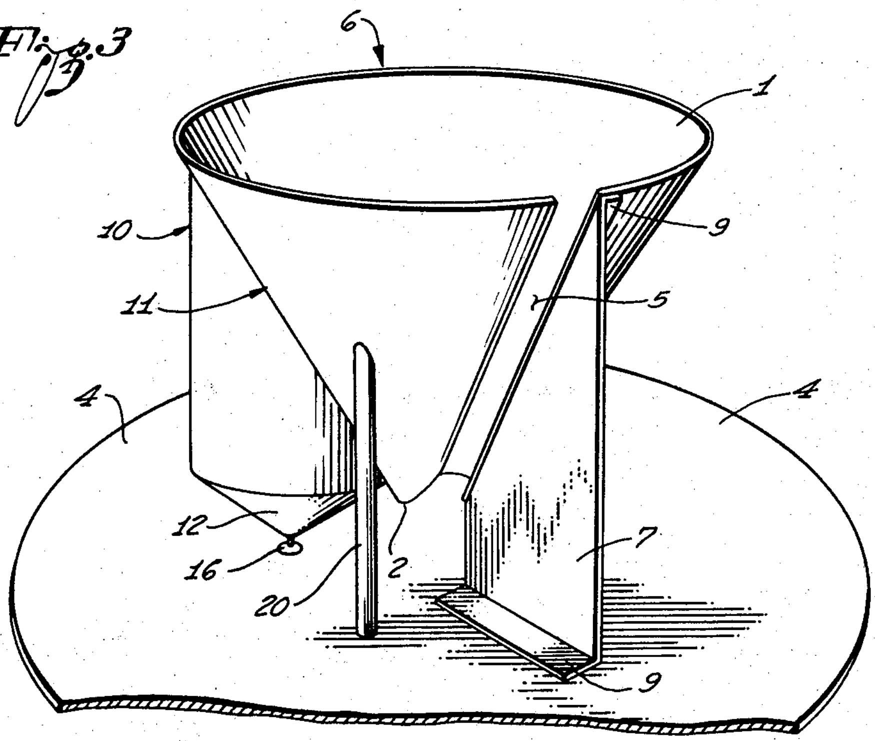
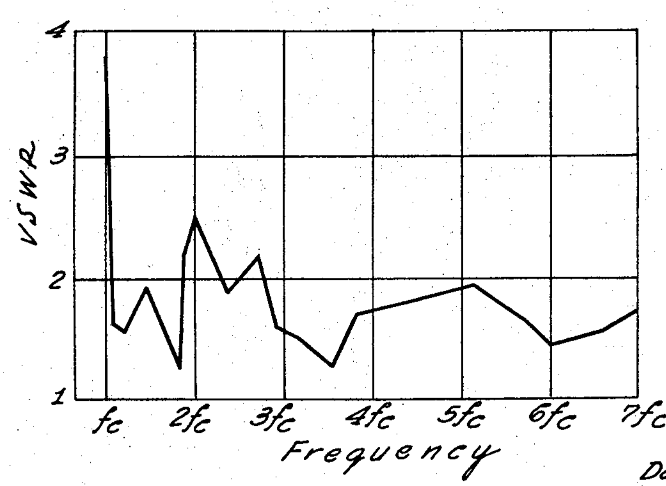


Fig. 4



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1

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SLOTTED CONE ANTENNA

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8 Claims. (Cl. 343—767)

The present invention relates to electromagnetic antennas, and more particularly, to a broadband, omnidirectional, vertically polarized antenna of a modified conical form.

In the HF, VHF and UHF portions of the radio spectrum, for example, there are many applications requiring antenna size to be kept at a minimum while maintaining as large or broad as possible the frequency band characteristics. Conventional antennas operate efficiently, or relatively so, over only a 2:1 frequency range at best, without resorting to tuning means. This is because such antennas are usually of the resonant type having a quality factor (Q) on the order of one (1) or more. Thus, they really cannot have a broadband characteristic.

It is an object of this invention to provide a compact broadband antenna having a much smaller size (height and diameter) than previous antennas of its kind, while still retaining equal or better bandwidth and other electrical characteristics.

It is a further object to provide such an antenna which is vertically polarized and has an omnidirectional radiation pattern.

A further object is to provide such an antenna which is light in weight, mechanically rugged and has a low profile, i.e., small height.

Our invention comprises, in its preferred form, a slotted inverted cone-like member, fed by a cylindrical offset feed member connected at the center of its lower end to a coaxial transmission line extending through a conducting ground plane, the cone being connected to the ground plane through a vertical conductive strip or plate at one side of the slot.

The present invention will be more fully understood by reference to the detailed description of specific apparatus to follow, and to the accompanying illustrative drawings, wherein:

FIGURE 1 is an elevation view of the present antenna invention, showing its mounting on a conductive ground plane.

FIGURE 2 is a plan view of the antenna, showing more particularly the slot and feed cylinder.

FIGURE 3 is a perspective view of the antenna erected on its ground plane.

FIGURE 4 is a graph showing the relationship of the voltage standing wave ratio (VSWR) versus frequency, of a typical antenna as shown in the other figures.

Referring first to FIGURES 1 and 3 for a detailed description of a preferred embodiment, a generally frustoconical member **1** (hereinafter referred to as a cone) has its apex end **2** pointing perpendicularly to and spaced from a conductive ground member **4**. The angle A of cone **1** may be about 60 degrees, for example. Apex end **2** is open, and a substantially constant-width slot **5** is provided in the surface of cone **1** all the way from a base end **6** to the apex end **2**, where it is seen that the slot **5** is preferably substantially perpendicular to the base end **6**. (See FIGURE 2.) The diameter of apex end **2** may be smaller, but the actual point of the cone is preferably not present. The slot **5** could obviously be centered with respect to the apex end **2**, if desired.

A vertical plane plate member **7** is conductively connected to the cone **1** adjacent to slot **5**, and extends downward to conductively connect to ground plane **4**. These connections may be in the form of flanges **9** welded or

2

soldered to the component parts, for example. Plate **7** preferably contacts cone **1** for substantially the full side length of the latter, although it may be connected to cone **1** for a shorter distance with less than optimum desired results. Plate **7** may thus serve as a support for cone **1**, in addition to its primary antenna function to be described later.

Approximately opposite to plate **7** across the cone **1** is a feed cylinder **10** positioned vertically under the cone surface. It is offset from the axis of cone **1**, and thus differs from conical antenna structures fed at the apex. The upper portion of cylinder **10** ends at a closed curved intersection **11** with the cone **1**. The diameter of cylinder **10** is chosen so that the intersection **11** preferably extends substantially the full length of the side of cone **1**.

The lower end of feed cylinder **10** is closed by a preferably conical bottom **12** which may have a cone angle B of about 110 degrees, for example. Bottom **12** may be shaped otherwise, but should taper or curve symmetrically to a low central position. The apex of bottom **12** is positioned slightly above the ground member **4** and has electrically connected thereto an inner conductor **14** of a coaxial transmission line **15**. Inner conductor **14** passes through and is insulated from ground member **4** by a suitable non-conductive sleeve or grommet **16**, and a coax line socket **17** mounted on the lower side of ground member **4** electrically connects the outer conductor **19** of transmission line **15** to the ground member **4**.

Transmission line **15** leads to a transmitter or receiver (not shown) as the case may be.

If desired, non-conductive supports **20** (FIG. 3) may be installed between the cone **1** and ground member **4**. Ground member **4** is preferably about 1.5 times the cone diameter or larger.

When operated with the ground member **4** in a normally hoizontal position, this antenna radiates vertically polarized, omnidirectional electromagnetic waves. The antenna is non-resonant, and appears to the input as a high-pass filter, having a Q value of much less than one. The low-frequency cutoff f_c is determined approximately by the height of the antenna, the height being only one-eighth wavelength at the lowest operating frequency. It is noted that this is only half the size of an equivalent discone antenna, each with the same low frequency cutoff.

This antenna is an electrical hybrid radiating structure. That is, in the lowest octave mode of operation, the major radiating element is the trapezoidal plate or leg **7**; and for operation above the first octave of frequency, the primary radiating element is the feed cylinder **10**, thus acting similar to a series-fed discone antenna. In the lower mode of operation, the feed cylinder **10** functions to properly excite the structure, and the antenna appears as a shunt fed, top loaded, transmission line antenna.

The present antenna exhibits a radiation efficiency of greater than 40% over a 6:1 frequency band, as referenced to a standard quarter-wave vertical monopole. The upper frequency limit is many octaves above the low cutoff frequency, and the field pattern in the principal horizontal plane remains omnidirectional over at least a 2-octave spread (4:1 frequency bandwidth). The voltage standing wave ratio of a typical embodiment, as shown in FIGURE 4, is much less than 3:1 from mid-VHF to upper UHF range. It is less than 2:1 over most of this range.

The cone angle A of 60 degrees mentioned before can be varied to quite an extent, and may be between 20 and 120 degrees, for example. At the lesser angles, the antenna characteristics become similar to those of a resonant monopole, while at the greater angles, the bandwidth becomes limited.

The location of the feed cylinder **10** with respect to the plate **7** is not critical; a location in the range of 180 to 220 degrees from plate **7**, counter-clockwise looking down on the slotted cone, being preferred. The width of the slot **5** may be from one to two inches in the VHF–UHF ranges, for example.

The cylindrical shape of the feed cylinder **10** contributes to the broadband response. A conical feed member might be employed to result in a similar relative size of the intersection line **11**, but the results would not be as good. The feed member **10** might have an oval or other cross section, however. The particular shape of the bottom **12** affects the impedance value of the antenna as seen by the transmission line **15**. The cone angle B of 110 degrees mentioned before may be between 60 and 130 degrees, for example. A 50-ohm match is obtained when angle B is about 90 degrees.

The low cutoff frequency f_c is determined by evaluating the geometric mean quarter-wave resonant frequency of the structure. It may be estimated from the formula

$$f_c = \sqrt{f_1 f_2}$$

where

$$f_1 = \frac{C}{4(h_1 + c_1\sqrt{\epsilon_r}}$$

and

$$f_2 = \frac{C}{4(h_2 + c_2)\sqrt{\epsilon_r}}$$

Dimensions h_1 and h_2 are shown in FIGURE 1. c_1 and c_2 are the circumferences of the apex end **2** and base end **6**, respectively, of the cone **1**. C is the velocity of light, and ϵ_r is the effective relative dielectric constant of the antenna medium.

For convenience, the imaginary apex of cone **1** may be located on the ground member **4**.

As shown, the feed cylinder **10** is hollow for purposes of convenience and light weight. Also, the cone **1** is solid across the intersection **11** for simplicity, but could be cut away inward of the intersection line **11** if desired. Further, the cone, plate, and/or cylinder may be formed of mesh or other grid-like material or the like. Moreover, the cone member **1** need not be a right circular cone, but may be oval or elliptical shaped to occupy a space longer than it is wide. As recited in the appended claims, the words "cone" and "cylinder" are deemed to include such variations as mentioned herein.

It is thus seen that an extremely rugged and compact shape is achieved by the present antenna. A true broadband function is provided, and no tuning mechanisms are required. Some examples of specific applications of this invention are in communications, countermeasures, and navigational systems such as beacons. The antenna can be adapted to produce more horizontal polarization.

While in order to comply with the statute, the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise the preferred form of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

What is claimed is:

1. An antenna comprising an inverted, slotted cone, an offset feed member intersecting the surface of said cone, and a ground leg connected to said cone near the slot therein.

2. Apparatus in accordance with claim **1** including a ground plane member substantially perpendicular to the axis of said cone and spaced from the apex end thereof, said leg connected to said ground member.

3. Apparatus in accordance with claim **2** wherein said feed member has means at its lower end for connection to a transmission line, said means passing through and insulated from said ground member.

4. Apparatus in accordance with claim **2** wherein said feed member extends down nearly to said ground plane member, and including transmission line connection means mounted on said ground member, said line connection means comprising a first conductor means passing through said ground member, insulated therefrom and connected to the bottom of said feed member, and a second, separate, conductor means conductively connected to said ground member.

5. Apparatus in accordance with claim **1** wherein said feed member and said leg each intersect said cone for substantially the full length of the side thereof.

6. Apparatus in accordance with claim **1** wherein said feed member is cylindrical, the end thereof opposite its intersection with said cone being closed by a second cone of substantially greater central angle than said slotted cone, and means for connecting the apex of said second cone to one conductor of a transmission line.

7. An antenna comprising:

(1) an inverted frusto-conical member, means defining a slot extending from the apex end of said member through the base;

(2) a ground plane member spaced from said apex end and substantially perpendicular to the axis of said conical member;

(3) a substantially planar ground leg erected substantially perpendicular to said ground member and connected to said conical member for a substantial extent thereof adjacent to said slot;

(4) a feed member having the form of a surface of revolution offset from said conical member axis, said feed member being connected at its upper end to said conical member along an intersection line therebetween and extending downwardly toward said ground member; and

(5) a means at the lower end of said feed member for connecting a transmission line conductor thereto.

8. Apparatus in accordance with claim **7** wherein said feed member is a cylinder parallel to the axis of said frusto-conical member, the upper end of said cylinder intersecting said frusto-conical member in a closed curved intersection line occupying a major portion of the distance from the apex end to the base end of said conical member, the lower end of said cylinder being closed by an inwardly tapering bottom to a substantially central position beneath said cylinder, said central position forming a connection point for said transmission line.

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