

Aug. 20, 1963

A. F. WICKERSHAM, JR., ETAL  
LOG PERIODIC TYPE ANTENNA MOUNTED ON GROUND  
PLANE AND FED BY TAPERED FEED

3,101,474

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2 Sheets-Sheet 1

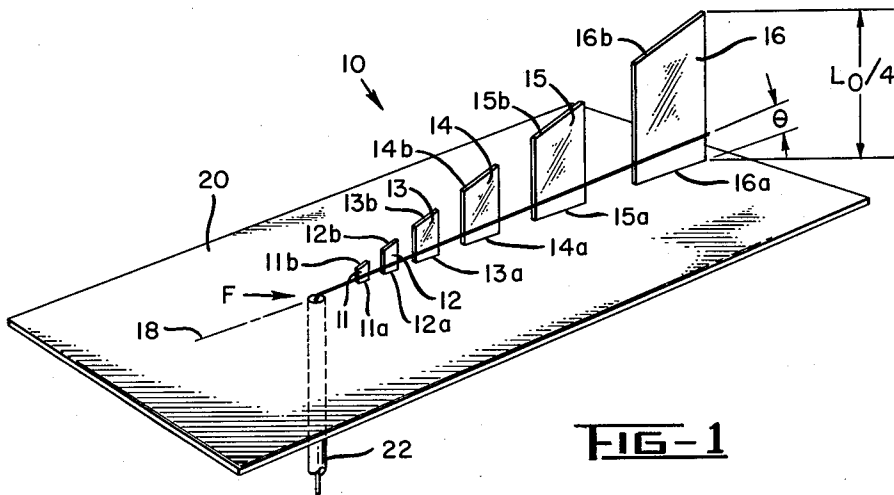


FIG-1

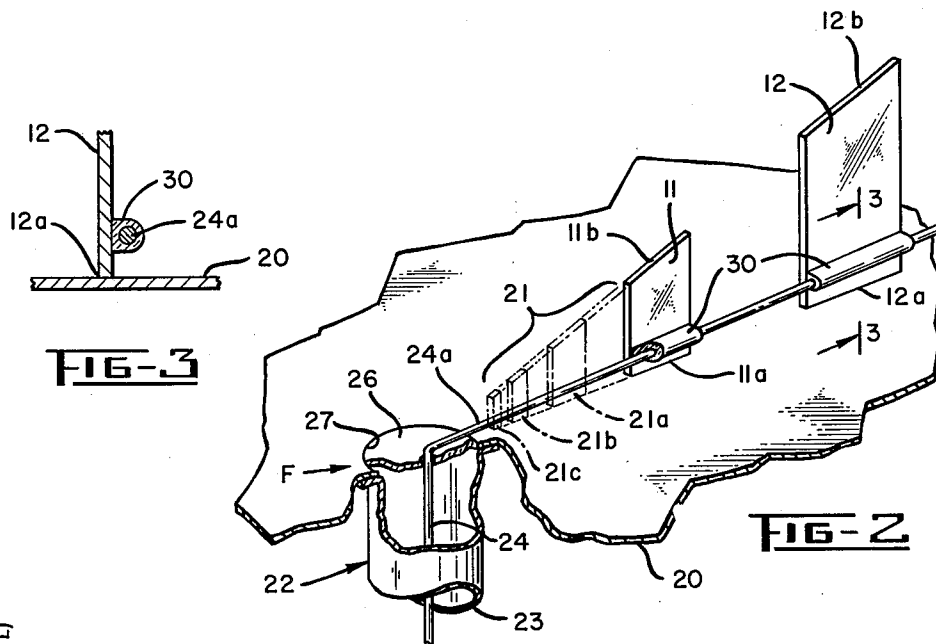


FIG-2

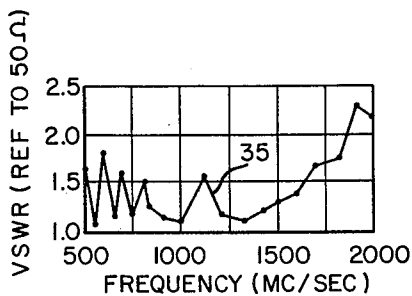


FIG-3

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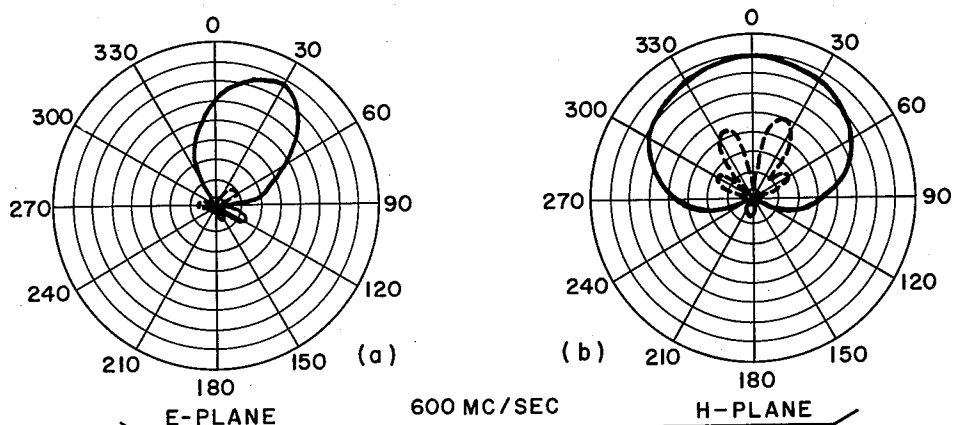
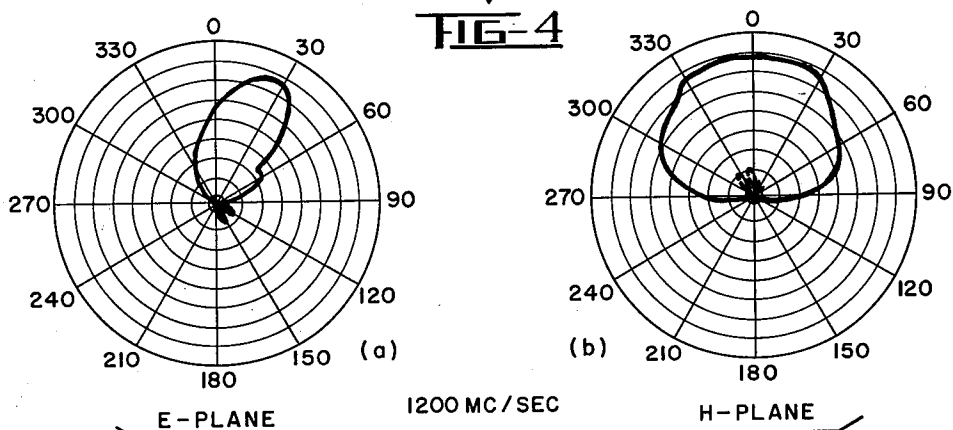
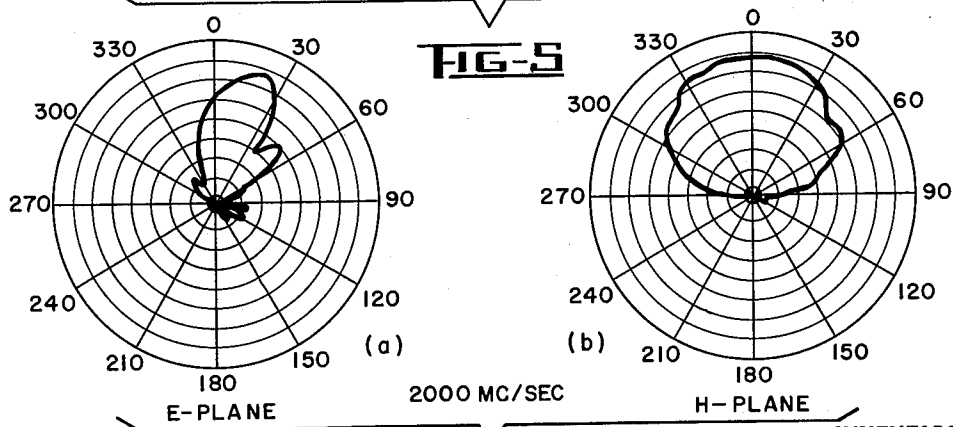
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## LOG PERIODIC TYPE ANTENNA MOUNTED ON GROUND PLANE AND FED BY TAPERED FEED

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This invention relates to antennas, and more particularly to a broadband "tapered" array utilizing radiating elements whose lengths are functions of element position in the array. The antenna with which this invention is concerned belongs to a family known as Pseudo-Infinite, Logarithmically Periodic (PILP) Antennas.

PILP antennas have the desirable characteristic of maintaining a relatively constant radiation pattern and impedance over indefinitely large bandwidths. However, because of the asymmetry or complementary nature of the radiating components, no satisfactory means has been found for exciting such antennas in conjunction with the counterpoise or ground plane. As a result, PILP antennas have generally been restricted to optimum performance only in an essentially "free space" environment.

Our invention concerns a PILP-type antenna which operates with a ground plane as an essential part of the antenna. Briefly, the antenna physically comprises a series of radiating elements whose lengths and spacings increase uniformly with increasing distance from each element to a feed point, and where the elements are shunt-excited by one-half of a tapered two-wire transmission line. The transmission line is developed from a coaxial line and the point of transition from the coaxial line to the half of the twin-wire feed line is called the "feed point." The ground plane comprises a suitable planar conducting surface having dimensions large compared to those of the radiating elements, and may comprise the surface of the earth or a conducting sheet. The outer conductor of the coaxial line is electrically connected to the ground plane or counterpoise at the feed point and the inner conductor is extended to become half of a tapered two-wire transmission line which is electromagnetically coupled to successive elements or radiators at increasingly greater distances above the ground plane. In short, the inner conductor diverges from the ground plane and this is what is meant by "tapered."

An object of our invention is the provision of a pseudo-infinite logarithmically periodic antenna that is capable of operating in conjunction with the ground plane.

Other objects of our invention will become apparent from the following description of a preferred embodiment thereof, reference being had to the accompanying drawings in which:

FIGURE 1 is an isometric view of an antenna and ground plane embodying our invention;

FIGURE 2 is a greatly enlarged fragmentary sectional view of a portion of FIGURE 1;

FIGURE 3 is a transverse section of the antenna taken on line 3—3 of FIGURE 2;

FIGURES 4-6, inclusive, are radiation patterns of the antenna over a 3 to 1 frequency range; and

FIGURE 7 is a plot of voltage standing wave ratio against frequency for an antenna embodying our invention.

Referring now to the drawings, a preferred embodiment of the invention comprises an antenna 10 having conducting elements 11-16, inclusive, arranged in a row along the axis 13 of the antenna. These conducting elements may be plates as shown which are parallel to each other and are in a common plane and which are electrically connected to and supported on a conducting surface 20 extending normal to the plane of the plates.

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The conducting surface 20 is a so-called "ground plane" having real dimensions substantially greater than the dimensions of plates 11-16 and may comprise the surface of the earth, a counterpoise, or a conducting sheet such as copper plate.

Plates 11-16, inclusive, have lower edges 11a-16a, respectively, which intersect and make electrical contact with surface 20. The upper edges 11b-16b are inclined relative to surface 20 so that the lengths of successive plates increase in accordance with a predetermined ratio in a direction from one end of the antenna to the other, i.e., from the left to the right as viewed. The widths of successive plates and the interplate spacings as measured along the axis of the antenna, likewise increase in accordance with a predetermined ratio. In sum, the physical dimensions and spacings of conducting elements 11-16 vary monotonically from a minimum at one end of the antenna to a maximum at the other end in progressive increments of a predetermined ratio.

While theoretically an antenna embodying this invention could be constructed having a semi-infinite bandwidth, in practical form the antenna is suited to operate over a given finite frequency of range, the length  $L_0/4$  of the largest radiating element 16 roughly corresponding to one-quarter of the largest operating wavelength of the required band. The lengths and separations of the remaining elements are uniformly decreased or tapered to vanishingly small dimensions so that essentially there is no "smallest" operating wavelength, and all other dimensions of the elements are kept in constant ratios to the lengths. The antenna characteristics, then, with respect to directivity, beam shape and impedance, remain substantially the same for wavelengths less than  $L_0/4$  because a part of the antenna has physical dimensions corresponding to any operating frequency within that range. Because antenna arrays are discrete structures, the frequency bandwidths of individual radiating elements are chosen to overlap in order that the periodicity of radiation patterns with changes in frequency will be minimized or eliminated entirely.

The number and size of radiating elements used in any one antenna depends upon the frequency range over which the antenna is operative. While the size of the smallest element 11 is dictated by the upper limit of the operating range, in practice it was determined that a tapered extension 21, indicated in broken lines in FIGURE 2, improved the impedance match of the antenna to the feed line and thus optimized antenna performance. The extension 21 may be a solid plate, or may, alternatively, comprise successively smaller radiating elements 21a, 21b and 21c which are spaced progressively closer together.

In order to feed electromagnetic wave energy to the antenna (if it is used as a transmitter) or to receive intercepted waves from the antenna (when it is used as a receiving antenna) over a broad range of frequencies, a relatively frequency-insensitive feed system is employed. In the preferred embodiment of the invention, the feed system comprises a coaxial line 22 having an outer conductor 23, see FIGURE 2, and an inner conductor 24 which join the antenna at the "feed point" indicated at F in FIGURES 1 and 2. The outer conductor 23 of the coaxial line terminates at and is electrically connected to surface 20 and the inner conductor 24 is supported in and extends through a dielectric washer 25 secured in a suitable opening 27 in the conducting surface 20. The extension 24a of conductor 24 above surface 20 is bent over at the feed point and extends from this bend for the full length of the antenna closely spaced to the conducting elements 11-16. The conductor 24a is "tapered," i.e., its spacing from surface 20 increases progressively from the feed point F to the last

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conducting element 16 so that the conductor makes an angle  $\phi$  with the conducting surface. The conductor 24a is electromagnetically coupled to and insulated from each of the conducting elements 11—16, and in order to support the conductor in this position relative to the conducting elements, insulator brackets 30, see FIGURE 3, through which the conductor extends, are secured to the sides of the plates.

A principal advantage of the above described counterpoise antenna is that it is ideally suited to operation in conjunction with a conducting surface or ground plane. Indeed, the ground plane is an essential element in the entire combination. At any particular frequency, the off-resonant ones of the conducting elements 11—16 of the antenna 10 are practically uncoupled and contribute little to the operation of the antenna. This is believed to account for radiation patterns that are essentially constant and practically free of disturbing lobes or pattern "break up."

By way of example, an antenna embodying our invention and having the following dimensions and operating characteristics was built and successfully operated:

Area of ground plane 20..... 20" x 40"  
Number of conducting plates..... 6  
Distance from feed point F to remote edge of largest conducting element 16..... 16"  
Angle of inclination of top edges of plates .....degrees... 20.5  
Plate Dimensions:

|                                | Width, inches   | Mean Height, inches | Spacing, inches |
|--------------------------------|-----------------|---------------------|-----------------|
| Plate 11 and Extension 21..... | 2 $\frac{1}{8}$ | $\frac{9}{16}$      |                 |
| Plate 12.....                  | $\frac{5}{8}$   | 1 $\frac{1}{4}$     | $\frac{7}{16}$  |
| Plate 13.....                  | $\frac{7}{8}$   | 1 $\frac{3}{16}$    | $\frac{3}{4}$   |
| Plate 14.....                  | 1 $\frac{1}{4}$ | 2 $\frac{5}{8}$     | 1 $\frac{1}{4}$ |
| Plate 15.....                  | 1 $\frac{1}{2}$ | 3 $\frac{1}{16}$    | 1 $\frac{1}{4}$ |
| Plate 16.....                  | 2 $\frac{3}{4}$ | 5 $\frac{1}{16}$    | 2 $\frac{1}{4}$ |

Coaxial cable.....ohms... 50  
Frequency range.....mc... 600—2000  
Average VSWR..... 2.75

The performance of the above described antenna is shown in part in FIGURES 4—7, inclusive. The E- and H-plane radiation patterns cover a frequency range of 600 to 2000 megacycles per second, and additional bandwidth is achieved by increasing the number of conducting elements. The E-plane patterns shown in FIGURES 4a, 5a and 6a are those patterns in which the electric polarization vector is orthogonal to the ground plane and which would correspond to vertical "cuts" in the radiation pattern of the large structure mounted on the earth's surface. The H-plane patterns are taken in a plane orthogonal to the E-plane and inclined 10 degrees to the ground plane. The ground plane intersects the E-plane patterns at zero degrees. These patterns show a well-formed beam of about 33 degrees half-power beamwidth in the E-plane and 118 degrees beamwidth in the H-plane. This corresponds to about 10 db directive gain above an isotropic radiator, and gain and pattern shape are almost constant over the entire frequency range. The beam is symmetric in the H-plane, and in the E-plane is inclined about 25 to 30 degrees to the ground plane. Cross-polarized radiation is indicated by broken lines in the figures. The voltage standing wave ratio plots 35 for

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the antenna described above are shown in FIGURE 7. This VSWR can be optimized and an improved match can be achieved with a coaxial line characteristic impedance of 50 ohms; the nominal antenna impedance in the latter situation is about 35 ohms. Input impedance can be controlled by choice of position and size of the tapered transmission line.

Changes, improvements and modifications of the above described embodiment of our invention may be made by those skilled in the art without departing from the precepts and spirit of the invention. The scope of the invention is defined in the appended claims.

We claim:

1. In combination, a ground plane and a broadband antenna having an axis comprising a plurality of parallel axially spaced conducting elements projecting away from said ground plane, each of said elements being electrically connected to said ground plane, the linear dimensions and spacings of successive ones of said elements increasing in a direction from one end of the antenna to the other, a two-conductor transmission line for feeding electromagnetic wave energy to said elements, one of said conductors being electrically connected to said ground plane, the other of said conductors extending the full length of the antenna closely spaced to and insulated from said conducting elements, said other conductor traversing said conducting elements at progressively increasing distances from the ground plane in a direction from said one end of the antenna to the other.

2. A broadband antenna comprising a planar conducting surface, a plurality of parallel spaced conducting elements arranged in a row in a first plane extending normal to said surface, said elements being electrically connected to said surface, the linear dimensions and spacings of said elements increasing in a direction from one end of the row to the other end, and a coaxial line having an outer conductor and an inner conductor, said outer conductor being electrically connected to said surface, said inner conductor having an extension parallel to said first plane and spaced from and electromagnetically coupled to said elements, the spacing between said extension of the inner conductor and said surface increasing in a direction from said one end of the row to the other.

3. In combination with a ground plane, a broadband antenna comprising a plurality of parallel spaced conducting plates arranged in a row in a first plane extending normal to said ground plane, said plates intersecting and being electrically connected to said ground plane, the linear dimensions of and spacings between said plates increasing in a direction from one end of the row to the other, the edges of said plates opposite from ground plane lying in a plane diverging from said ground plane in a direction toward said other end of the row of plates, and a coaxial line having an outer conductor and an inner conductor, said outer conductor being electrically connected to said ground plane, said inner conductor having an extension disposed parallel to said first plane and being spaced from and electromagnetically coupled to said plates, the spacing between the extension of said inner conductor and said ground plane increasing from a minimum at said one end of the row to a maximum at the other.

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