July 6, 1965 R. F. H. YANG 3,193,831

LOGARITHMIC PERIODIC ANTENNA

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FIG. 1

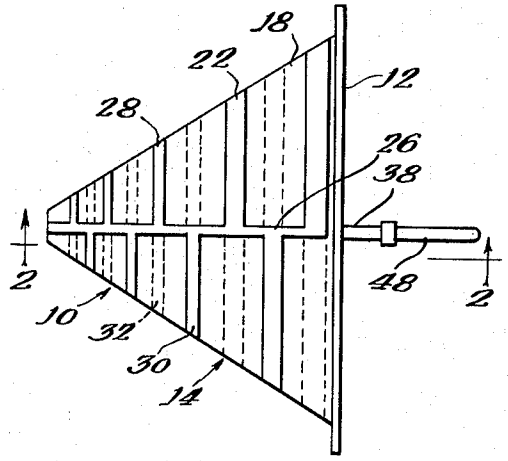


FIG. 2

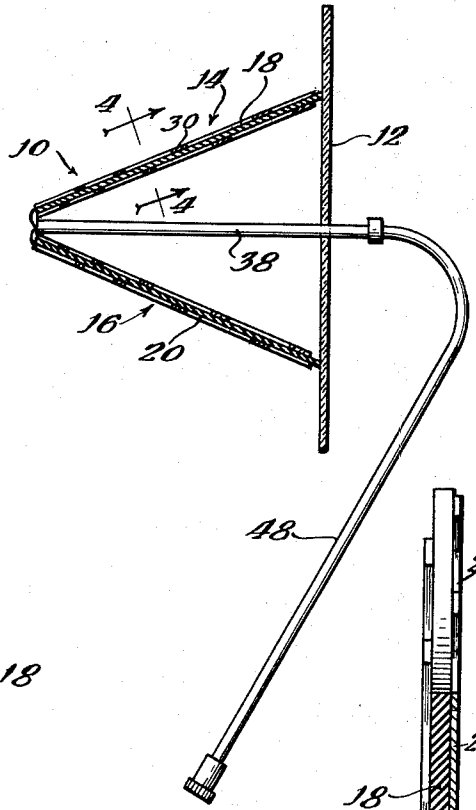
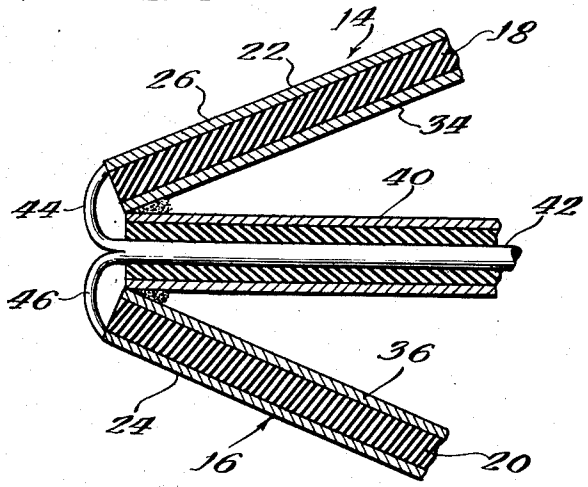


FIG. 3



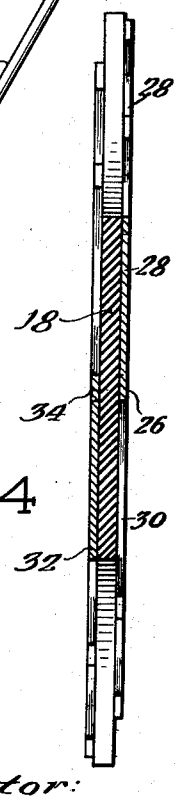


FIG. 4

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FIG. 5

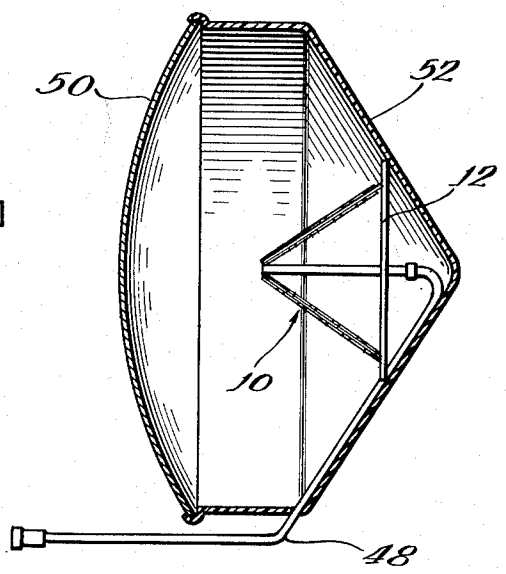


FIG. 6

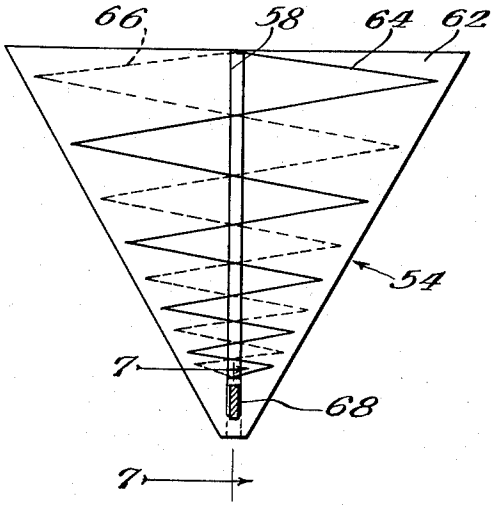
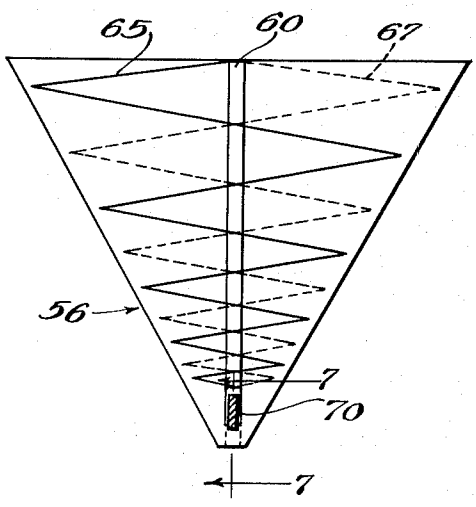


FIG. 6a



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FIG. 7

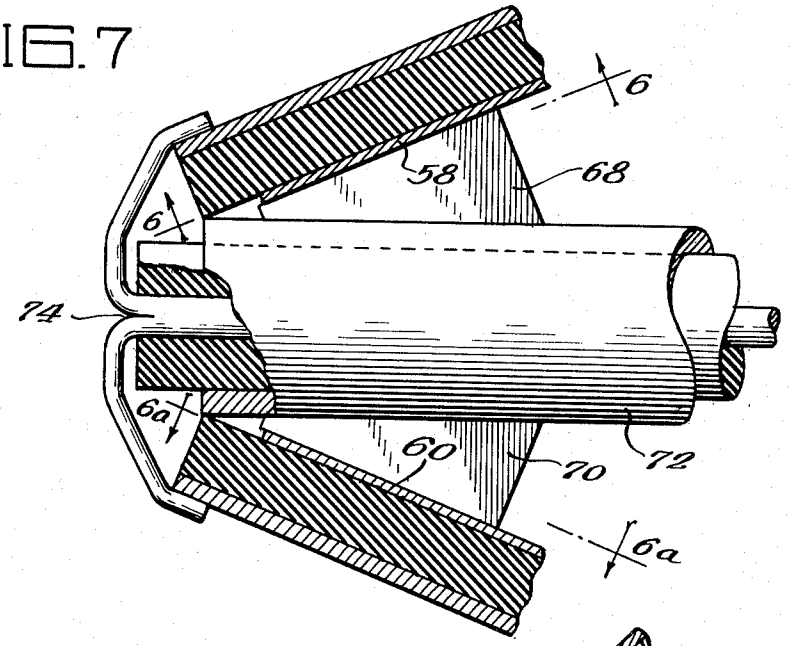
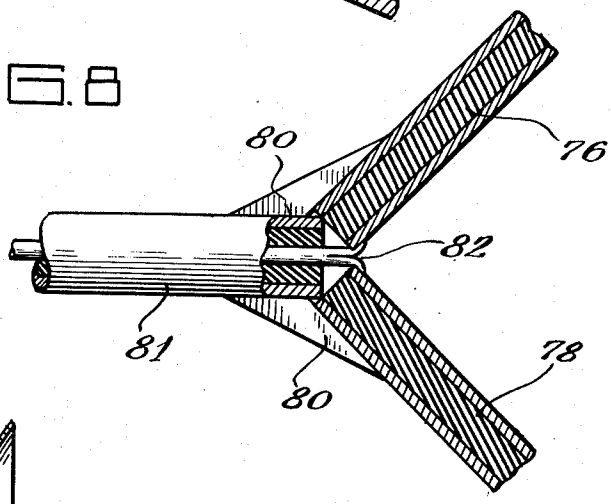


FIG. 8



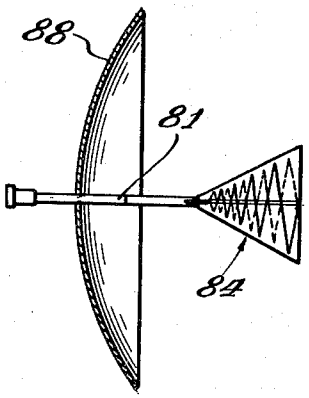


FIG. 9

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LOGARITHMIC PERIODIC ANTENNA

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Filed Nov. 22, 1961, Ser. No. 154,269
14 Claims. (Cl. 343—792.5)

This invention relates to antennas and more specifically to the wide-band type of antenna developed in many forms in recent years generally known as the logarithmic periodic antenna.

The construction of logarithmic periodic antennas in most common use employs a pair of tapered plane radiating portions, more or less triangular in shape, with the apexes positioned closely adjacent to each other, these radiating portions lying in planes perpendicular to the plane of the center-lines of the two triangular portions. Various designs of this general type of antenna have been devised, having in common the fact that the radiating portions each comprise a set of conductor elements having a straight stem conductor extending away from the apex or vertex of the triangle which is at the apex of the antenna, along the center-line of the triangular element, with conductors extending from this center-line or stem conductor, alternated on either side thereof in the plane of the element, these extending conductors or poles of the antenna being of increasing length with increasing distance from the vertex, thus forming the generally triangular element. Additionally, within the triangle thus formed, the width, as well as the length, of each of the poles is normally tapered. The theory of such antennas has been extensively set forth in the literature, and is now well-known in the art along with the selection of dimensions and similar characteristics for the covering of desired frequency ranges. Such antennas produce, because of their geometry, substantially uniform response over a wide band of frequencies, the pairs of poles on the two elements or half-portions which contribute the most to the radiation at any given frequency shifting with the frequency of operation over the desired range, the optimum designs, including the tapering of the width or thickness of the elements described above, also maintaining substantially constant impedance characteristics over the entire band of operation.

Such antennas are formed in a variety of manners, such as from stampings of sheet conductors, or by formation with wires or bars, or by printing techniques.

The common forms of such antennas employ one of such conducting elements in each of the two intersecting planes, the teeth or poles on one of the elements being complementary to those on the other, i.e., the teeth on one being located in opposition to the gaps between the teeth on the other, on the respective sides of the plane of the center-lines. In a more refined form, two of such simple structures are "stacked," and complementary conductor elements are employed in both of the half-portions, a conductor element being added to each of the simple half-portions thus described in a closely adjacent parallel plane, with the inner element of one half-portion fed in phase with the outer element of the other half-portion. Although even the simpler form produces a high degree of directivity, when properly designed, in the direction of the apex of the antenna, the stacking arrangement just mentioned is frequently used for the purpose of even further improving the gain.

In U.S. Patent 2,977,597, there is described a variant of the logarithmic periodic antenna in which the direction of radiation is deliberately split into two beams or lobes by employing mirror-image symmetry with respect to the plane bisecting the angle between the two half-portion planes, the corresponding teeth or poles on the two otherwise-identical conductor elements being placed in corresponding, rather than complementary, positions. These two mirror-image elements are fed in opposite phase, to produce a pattern having a null in the usual maximum direction, but having fairly sharp symmetrical lobes at the same angle with respect to the antenna axis.

Logarithmic periodic antennas are, as is well-known, capable of uniform performance over a wide frequency band to an extent unattainable with other approaches to wide-band antenna construction. However, one serious limitation heretofore existing on the widespread use of such antennas lies in the rather elaborate constructions practically required for the feeding of the antenna in order that the feed-line will not produce electrical unbalance of the two half-portions, thus destroying the performance of the antenna in respect to radiation pattern, impedance, or other characteristics. In most equipment, it is desirable or required that the antenna feed be a simple coaxial transmission line. The logarithmic periodic antennas heretofore known have required various more or less complicated construction to prevent the causing of unbalance by the presence of the outer conductor of the coaxial feed. It has been necessary to either use some modified form of unbalanced-to-balanced line converter (balun) of the type used with other balanced antenna constructions, or to resort to fairly complex feed arrangements, such as running the coaxial transmission line along the stem or center-line of the conductor element which is connected to the grounded side of the line, which in itself destroys the complete balance unless a further conductor similar to the outer conductor of the transmission line is also added to the stem of the conductor element which is fed from the center conductor of the transmission line, if the dimensions of the line are appreciable at the frequencies involved.

It is the principal object of the present invention to provide a form of logarithmic periodic antenna which is fed by a simple coaxial line in an extremely simple manner which permits the coaxial line to extend along the axis of the antenna without impairing the directivity, impedance bandwidth, or other desirable properties of this type of construction. This general object is achieved with a modified construction of "stacked" logarithmic periodic antenna, in which the conducting elements are oriented and fed in such a manner that there exists no electric field flux along a substantial region of the axis of the antenna, the coaxial transmission line being, at all points in the neighborhood of the antenna, in this field-free region where it accordingly has no effect on the balanced condition of the two angularly related half-portions with respect to ground, despite the fact that one conductor element or quarter-portion of each of the half-portions is grounded at the vertex end. Except for alteration of the connections of the conducting elements to the feed line, i.e., the opposite phasing of certain elements, the present construction may be described as the stacking of mirro-image elements such as those shown in Patent 2,977,597 in the general manner in which stacking was previously done with complementary conducting elements in the stacked construction mentioned above. When these mirror-image elements are stacked to produce a four-element structure in which the inner conductor elements or sets are mirror images of each other and the outer elements or conductor sets are likewise mirror images of each other, but complementary with the inner sets as regards tooth or pole orientation, and the inner conductor elements or sets are both connected to the same side of the line (i.e., fed in phase rather than out of phase as in the aforementioned patent), both outer conductor elements being fed in the phase opposite that of the inner elements, the directional pattern is in the form of a single

sharp lobe extending in the direction of the apex of the antenna. On the axis of the region between the two elements or half-portions of the generally pyramidal antenna assembly, there is no field because of the equipotential region created everywhere along this axis by the mirror-image relation of the inner and outer conducting elements, respectively. The coaxial line may thus be placed on this axis without upsetting the desired operation.

The invention is of particular advantage in connection with small antenna assemblies used as the feed for a parabolic reflector, in which the radiating assembly employed as the feed must be supported by the parabolic reflector or "dish." In one common type of single-frequency or narrow-band parabolic antenna assembly, the feed, such as a dipole-and-reflector, or a short length of waveguide, is supported by a rigid coaxial line which extends from the center of the reflector, and thus serves as both the transmission line and the mechanical support for the antenna structure which serves as the feed for the reflector. The present invention in the construction of logarithmic periodic antennas permits a similar type of support. A rigid coaxial line terminating at the apex of the wide-band logarithmic periodic structure as described above does not upset the balance of the two half-portions of the radiating antenna which serves as the feed, because of the symmetry mentioned. Of course, as in the case of any feed so supported, the presence of the axial transmission line has negligible effect as long as its diameter is not excessively large.

Accordingly, the present invention is particularly well adapted for use as the feed in reflector-type antenna assemblies, the location of a rigid coaxial line on the axis of the antenna, either extending forwardly from the apex, or extending between the half-portions from the apex to the base of the pyramidal structure, readily serves for mechanical support in addition to serving as the feed line. (It will of course be understood that terms such as "feed" and "feed line" as herein used refer both to receiving and transmitting devices, this terminology being commonly employed in the art in view of the known reciprocity of transmission and reception functions of antennas and their connections.)

Although the invention will readily be understood by persons skilled in the art from what has already been said, and many particular embodiments may be devised from the general principles discussed above, certain narrower objects and advantages of the invention will become apparent from the description of the advantageous embodiments described below and illustrated in the drawing in accordance with the patent laws.

In the drawing:

FIGURE 1 is a view in side elevation of an antenna embodying the invention;

FIGURE 2 is a view in seciton of the antenna of FIGURE 1 taken along the line 2—2 of that figure in the direction indicated by arrows;

FIGURE 3 is an enlarged fragmentary view of the tip or apex portion of the antenna, illustrating the manner of coupling of the coaxial transmission line to the conductor elements;

FIGURE 4 is an enlarged cross sectional view through one of the half-portions of the antenna of FIGURE 2;

FIGURE 5 is a more or less diagrammatic showing of the antenna of FIGURES 1 through 4 mounted as the feed for a parabolic reflector antenna assembly;

FIGURES 6 and 6*a* are views in elevation of resective members of a modified pair of logarithmic periodic antenna half-portions which may be used in accordance with the invention;

FIGURE 7 is a sectional view taken along the lines 7—7 in the direction indicated by arrows in FIGURES 6 and 6*a*, showing the assembly and connections of the half-portions illustrated in those figures;

FIGURE 8 is a fragmentary view showing another form of assembly of the antenna of the invention; and

FIGURE 9 is a view in section showing, more or less schematically, the construction of a parabolic antenna assembly employing as the feed thereof an antenna constructed in accordance with FIGURE 8.

Referring first to the embodiment of FIGURES 1 through 4, it will be seen that the antenna generally designated by the numeral 10 is mounted on a plate 12 of fiberglass or other similar dielectric material. The radiating portion is formed of two planar half-portions 14 and 16 mounted on substantially triangular insulating plates 18 and 20, respectively, of material similar to that of plate 12. The plates 18 and 20 are shaped substantially as isosceles triangles, oriented in planes perpendicular to the plane of their center-lines; the vertices or apexes of the plates are closely spaced to form the overall pyramidal shape characteristic of this type of antenna.

On the outer surfaces of the plates 18 and 20 are outer quarter-portion conducting elements or assemblies 22 and 24, respectively, each having a stem conductor 26 extending along the center-line from the vertex or tip of the antenna, with teeth or poles perpendicular to the center-line stem conductor 26 extending in both directions, the teeth or poles 28 extending laterally in one direction being offset or complementary to the teeth or poles 30 extending in the other direction. The stem 26 and the extending teeth or poles 28 and 30 are formed from a single sheet of suitable conducting material such as copper or aluminum, and their dimensioning and taper are determined in the manner usual in this general type of logarithmic periodic antenna. However, as best seen in FIGURE 2, the location or phasing of the laterally extending teeth or poles 28 and 30 on the respective outer quarter-portions is such that they form mirror images with respect to the plane bisecting the angle between the two half-portions.

An inner quarter-portion conductor element on the inner surface of plate 18 is formed similarly, but the teeth or pole conductors 32 laterally extending from the stem conductor 34 are located in the positions which are complementary to those occupied by the teeth or poles 28 and 30 on the outer quarter-portion 22 on the outer face of the insulating plate 18. The inner face of the plate 20 likewise bears a quarter-portion having a stem conductor 36 and teeth or poles forming a mirror image of those on the inner surface of the plate 18.

A rigid coaxial line 38 extends from the tip or apex of the pyramidal structure along the axis of the interior and through the plate 12 in the divergence plane of the center-lines.

As seen in FIGURE 3, the end of the outer conductor 40 of the coaxial line 38 is bonded by soldering or brazing to the ends of the stem conductors 34 and 36 of the inner quarter-portions of the conducting radiating assembly. The center conductor 42 of the coaxial line is of the twisted multi-wire type (this detail being omitted in the drawing for simplicity), and is split at the outer end into two symmetrical portions 44 and 46 which are respectively soldered or otherwise bonded to the ends of the stem portions of the quarter-portion conducting elements on the outer surfaces of the plates. It will thus be seen that the coaxial line is centrally located in the plane of the stem portions, and is thus in a location substantially free of electric field, and its presence does not in any way prevent the maintaining of complete electric balance with respect to ground of the two half-portions which form the radiating portion of the antenna, the mirror-image relation of the inner conducting elements and of the outer conducting elements in the stacked logarithmic periodic array producing the complete symmetry by which balance is maintained. A flexible coaxial cable 48 is connected to the outer end of the transmission line 38. As shown in FIGURE 5, the antenna 10, mounted on the plate 12, may be mounted at the proper position to serve as the feed for a parabolic

antenna assembly employing a reflector 50, the plate 12 upon which the antenna feed is mounted being suitably secured in a dielectric radome 52 suitably clipped or otherwise secured to the edge of the parabolic dish 50. In this instance, care is taken to orient the flexible coaxial cable input 48 entirely in the plane of the centerlines of the triangular radiating elements, this being the H-plane perpendicular to the electric field vector of the polarized radiation. The cable 48 is of course kept sufficiently far from the closest conductors of the radiating assembly so that the balance will not be affected.

A somewhat similar, but modified, embodiment of the invention is shown in FIGURES 6, 6*a* and 7. Here the triangular half-portions 54 and 56 are again formed with strip stem portions 58 and 60 mounted on the substantially identical insulating plates 62. However, in this instance the poles or teeth are formed on each side of the plate by zig-zag wires 64 through 67 strung back and forth across the surface and soldered to the center stem conducting strip where it is crossed to form, in a simple and inexpensive manner, effective triangular teeth or poles similar in function to the rectangular teeth or poles formed from a unitary sheet with the center stem in the embodiment previously described. As will be seen in FIGURES 6 and 6*a*, the stringing of the wires 64 and 65 on the inner surfaces of the triangular plates is such as to create a mirror-image relation, while the outer zig-zag wires 66 and 67 are also in mirror-image relation to each other, but form teeth or poles which are complementary to those formed on the inner or facing surfaces of the triangular insulators. It should be noted in this regard that mere orientation of identically formed half-portions will not produce the desired relationship, the mere duplication of either of the plates 54 or 56 producing, when two such identical plates are assembled, a conventional stacked antenna of the general type here involved, which will be unbalanced with respect to ground if the simple manner of connecting the coaxial feed is sought to be adopted.

Further advantage of the mirror-image construction of the stacked radiating elements of FIGURE 6 and FIGURE 6*a* is achieved in the assembly of FIGURE 7, in which there are inserted wedg-shaped metal plates 68 and 70 bonded at their respective edges to the outer conductor 72 of the rigid coaxial line, and to the inner ends of the stem strips 58 and 60, respectively, thus forming a completely rigid assembly which may readily and easily be entirely supported by the coaxial transmission line. In a manner similar to that previously described, the center conductor 74 of the coaxial line is split and symmetrically connected to the two outer quarter-portions. It will be observed in FIGURE 7 that in this instance the outer stem portions are formed with somewhat greater thickness than the inner stem portions, but the electrical symmetry produced by the mirror-image relationship of the parts, and the manner of connection, makes identity of the inner and outer structures unimportant in the preservation of balance of the radiators with respect to ground.

There is shown in FIGURE 8 another construction, in which the half-portions 76 and 78, of any construction including those described already, or others incorporating the mirror-image symmetry about the axis, are supported by triangular gusset plates 80 bonded by solder, brazing, etc., to the ends of the outer stem conductors and to the outer conductor of the rigid coaxial line 81. In this case, the center conductor 82 of the coaxial line 81 is connected symmetrically to the inner quarter-portions of the stacked array. The mirror symmetry here again prevents unbalance with respect to ground, so that the full advantage of the properties of the antenna may be obtained, while the antenna is both fed and supported by the rigid line, which in this case extends forward in the direction of the radiation from the apex of the structure. As shown in FIGURE 9, the device of FIGURE 8, employing half-portions made in the general manner of FIGURES 6 and 6*a*, is employed as a feed assembly 84 for a parabolic reflector 88, the coaxial line 81 being the sole support for the feed, as in the case of various narrow-band feeds.

It will be seen that the invention, although originating in a need for a simple feed for logarithmic periodic antennas of the unidirectional pattern characteristics discussed above, can also be adapted for use with other types of logarithmic periodic arrays. Further, persons skilled in the art will readily see, from the particular embodiments illustrated and described, many other constructions differing in appearance and detail, but nevertheless utilizing the basic teachings of the invention. Accordingly, the scope of the protection to be given the invention should not be limited by the particular embodiments herein described, but shall be determined in accordance with the structures as described in the annexed claims, and equivalents thereof.

What is claimed is:

1. In a logarithmic periodic antenna comprising a pair of tapered plane radiating portions disposed at an angle and fed at the apex, the improved construction having a coaxial transmission feed line in the plane bisecting the angle between the two portions and each portion having a grounded conductor element connected to the outer conductor of the transmission line and a complementary fed conductor element connected to the inner conductor of the transmission line, the grounded conductor elements and the fed conductor elements, respectively, of the two portions being of substantially indentical construction but having mirror-image symmetry with respect to said bisecting plane.

2. The improved logarithmic periodic antenna of claim 1 wherein each of the plane radiating portions comprises an insulating plate having an inner and an outer face, the grounded conductor elements and the fed conductor elements, respectively, being on the corresponding faces of both portions.

3. The improved construction of claim 2 wherein the coaxial line has a rigid outer conductor, and having rigid conductors extending between the outer coaxial line conductor and the grounded conductor elements to establish the grounding connection and support the two radiating portions.

4. The improved construction of claim 3 wherein the grounded elements are on the inner faces of the insulating members and the coaxial line is between the plane radiating portions.

5. The improved construction of claim 3 wherein the grounded elements are on the outer faces of the insulating members and the coaxial line extends away from the apex of the angle formed by the plane radiating portions.

6. In a logarithmic periodic antenna, two generally triangular half-portions having apexes positioned closely adjacent to each other to form the antenna apex and being perpendicular to the divergence plane which includes their center lines, each half portion comprising closely spaced mutually insulated inner and outer quarter-portions, each quarter-portion comprising an elongated center conductor in the divergence plane and conductors extending from the center conductor, the extending conductors being in complementary positions on the respective quarter-portions of each half-portion, all portions of the half-portions being in mirror-image relation to each other, and a straight coaxial transmission line extending in the divergence plane equally spaced from the two half-portions and terminating at the apex and having one conductor thereof connected at the antenna apex to the center conductors of the inner quarter-portions and the other conductor thereof connected at the antenna apex to the center conductors of the outer quarter-portions.

7. The antenna of claim 6 wherein the coaxial transmission line extends from the antenna apex in the region lying between the two half-portions.

8. The antenna of claim 6 wherein the coaxial transmission line extends from the antenna apex in the direc-

tion away from the region lying between the two half-portions.

9. A logarithmic periodic parabolic antenna assembly having a parabolic reflector and having the antenna of claim 8 as the feed, the coaxial transmission line rigidly extending from the center of the reflector and supporting and mounting the feed.

10. The antenna of claim 6 having rigid auxiliary conducting supports interconnecting the outer conductor of the transmission line and the central conductors of the quarter-portions to which said outer conductors are connected, said auxiliary conducting supports lying substantially entirely in the divergence plane and being symmetrical therein with respect to the two half-portions.

11. A logarithmic periodic antenna comprising a pair of spaced log periodic dipoles each having fed and grounded elements, the fed and grounded elements of dipoles being substantially identical except for being reversely oriented to form mirror images of each other with respect to a plane midway between them, and a coaxial transmission line in said plane having an inner conductor connected in substantially identical manner to both fed elements and an outer conductor connected in substantially identical manner to both grounded elements.

12. A logarithmic periodic antenna comprising a pair of spaced log periodic dipoles, each having two sets of complementary radiators, each set on one of the pair being substantially identical to the corresponding set on the other of the pair and located in mirror image relation thereto with respect to a plane midway between the pair, and a coaxial transmission line in said plane having one conductor connected in substantially identical manner to one pair of mirror-image sets, and the other conductor connected in substantially identical manner to the complementary pair of mirror-image sets.

13. An antenna comprising a pair of half-portions, each half-portion having a pair of mutually insulated closely spaced parallel stem conductors and poles extending from the stem conductors, the poles extending from one stem conductor at longitudinal points complementary to the poles extending from the other stem conductor, the stem conductors of both half-portions being substantially in a common plane and the extending poles forming planes substantially perpendicular to the common plane, the half-portions being in mirror-image symmetry with respect to a center plane midway between them, and a coaxial transmission line in said center plane and having an inner conductor connected to one of the stem conductors of one half-portion and its mirror-image stem conductor of the other half-portion, and an outer conductor connected to the other stem conductors of the respective half-portions.

14. The antenna of claim 13 wherein each of said half-portions comprises an insulating plate having the stem conductors and their extending pole conductors on opposite faces thereof.

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HERMAN KARL SAALBACH, *Primary Examiner.*