United States Patent

Ingerson

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[54] **LOG-PERIODIC SCALED DIRECTIONAL COUPLER FEED LINE FOR ANTENNAS**

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[52] **U.S. Cl.**.....**343/792.5**, 343/814

[51] **Int. Cl.**.....**H01q 11/10**

[58] **Field of Search**.....343/792.5, 811–819

[56] **References Cited**

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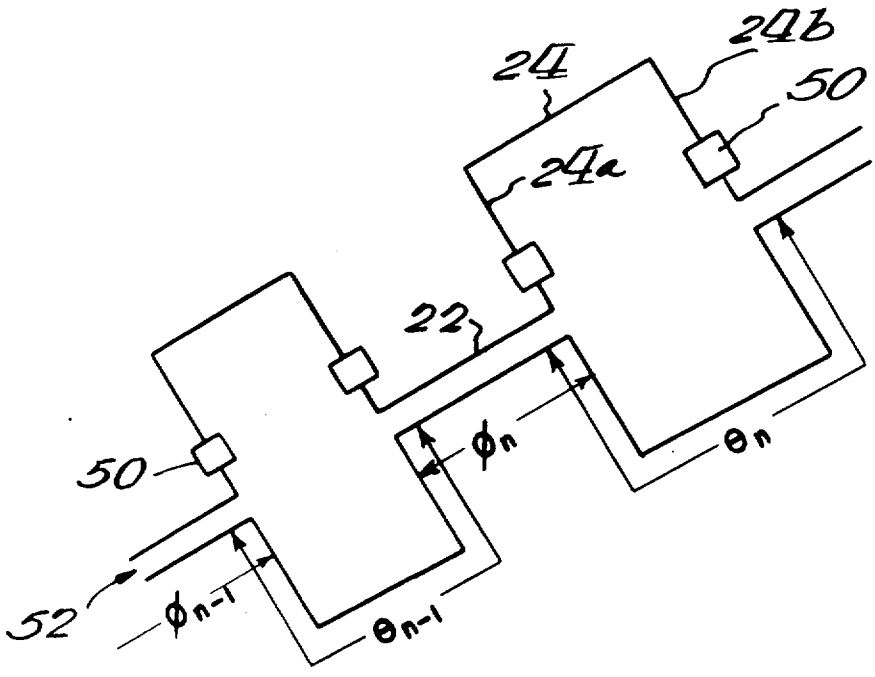
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[57] **ABSTRACT**

Log-periodic dipole, folded dipole, monopole, folded monopole, and slot arrays fed by a pair of coupled transmission lines which form a log-periodically scaled directional coupler feeder. Alternating scaled sections of coupled and uncoupled lines are employed as a feed unit for antenna arrays, with radiating elements provided in the uncoupled sections.

7 Claims, 10 Drawing Figures



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SHEET 1 OF 2

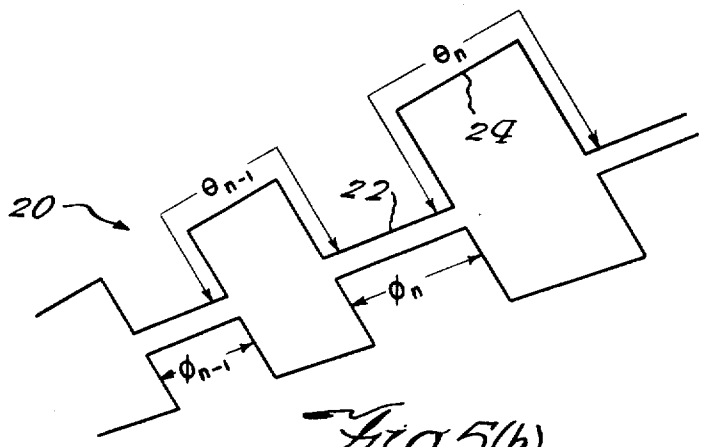


Fig. 1

Fig. 5(b)

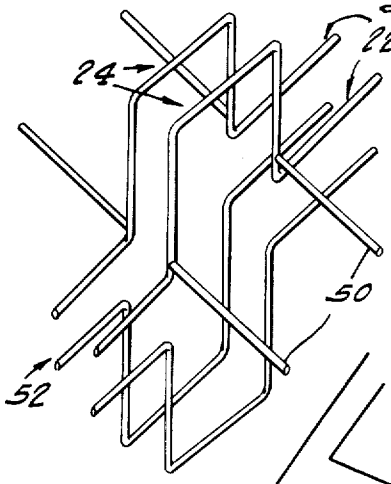


Fig. 2

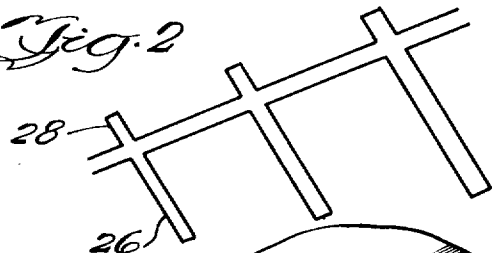


Fig. 3

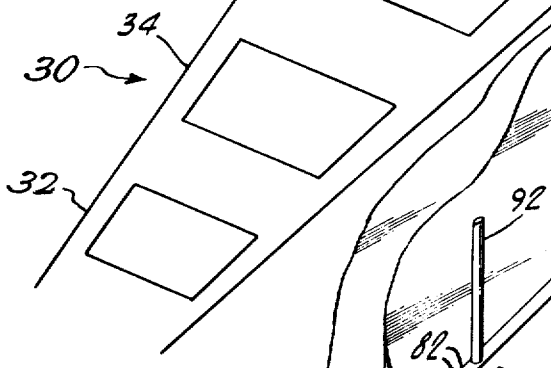
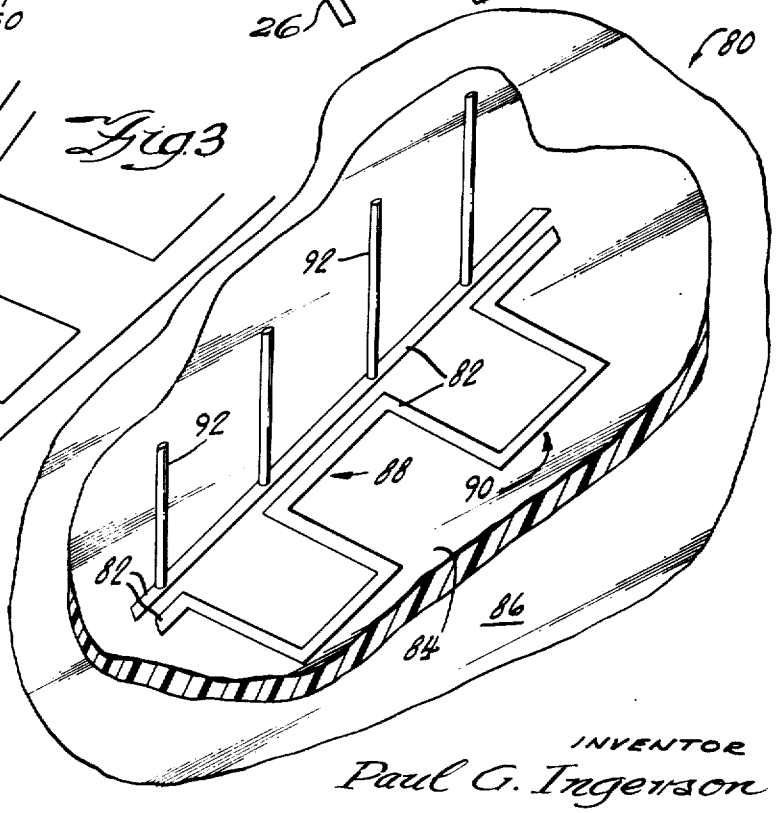


Fig. 9



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Fig. 5(a)

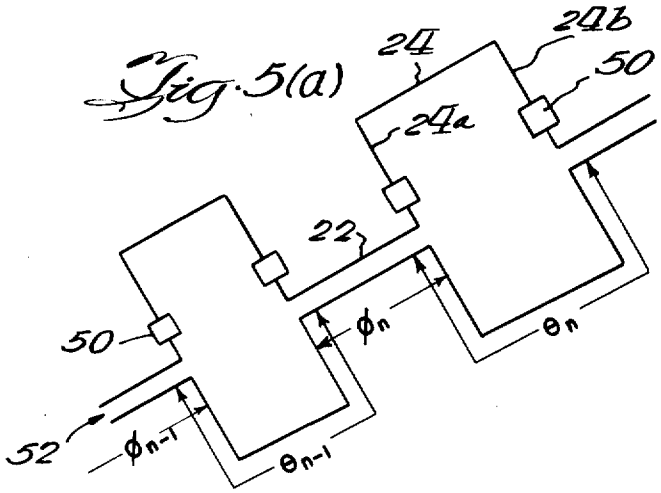


Fig. 4

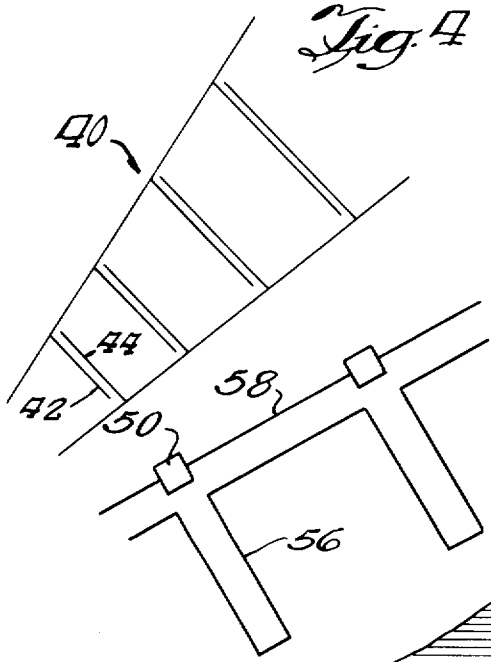


Fig. 6

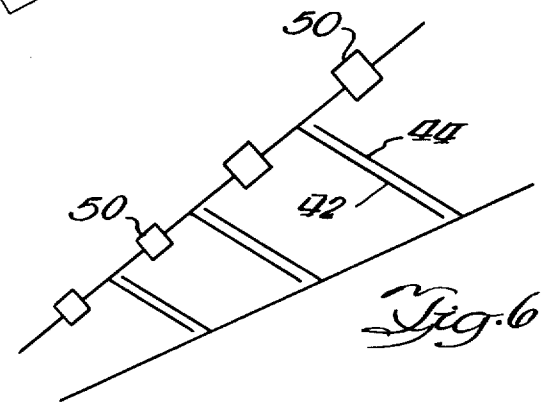
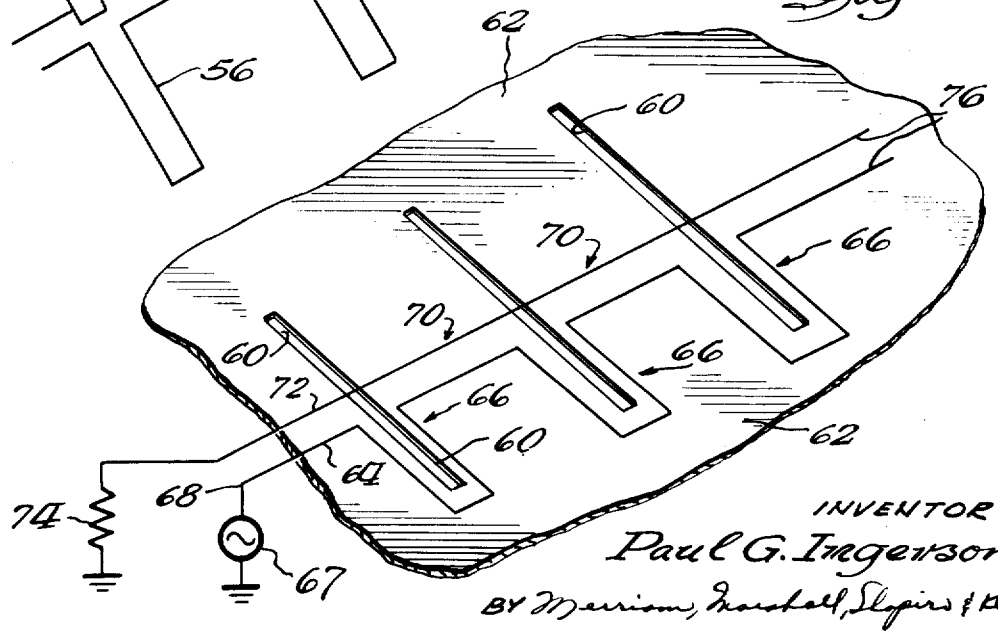


Fig. 7

Fig. 8



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LOG-PERIODIC SCALED DIRECTIONAL COUPLER FEED LINE FOR ANTENNAS

BACKGROUND OF THE INVENTION

This invention relates to antennas, and more particularly to a log-periodically scaled directional coupler feeder line for antennas.

The general purpose of the present invention is to overcome several limitations of the conventional log-periodic dipole array design by using a feeding system of two coupled transmission lines instead of a single line, so that in place of dipole radiating elements, folded dipole elements, with their inherent broadband performance, slots, and other types of radiators can be used. The construction of a compact monopole and folded-monopole over ground plane array is possible, as well as a log-periodic slotted ground plane array. Furthermore, by using two lines of different characteristic impedances to form the coupler, a wider range of mean input impedances may be achieved.

SUMMARY OF THE INVENTION

The structures illustrated in accordance with the principles of this invention form a new class of log-periodically scaled radiating systems. The basic feed unit is a pair of coupled transmission lines (not necessarily of the same characteristic impedance) which, due to special construction employing cascaded sections of line with adjacent sections differing in length by a common scale factor τ_1, form a log-periodically scaled directional coupler whose properties are such that essentially complete directional coupling of energy from one line to the other is possible. When the structure is designed so that essentially complete coupling occurs before energy reaches the rear end of the feed line, the structure is said to be independent of rear end truncation. In this case, the distribution of fields of appreciable amplitude on the two lines will scale and hence the coupling region scales with frequency. The energy which is then coupled onto the second line is directed completely back toward the source feed port, but on the second line (cf. with the conventional directional couplers).

Radiating elements are connected to the second line and are scaled in a log-periodic manner with τ_2 preferably equal to τ_1, though the scaling factor τ_2 for the elements need not be the same as the scaling factor τ_1 of the coupler, and in general, will be higher. When the radiating elements are correctly placed with respect to the coupling region and designed with respect to the mean impedance of the feed line, they will dissipate the energy by leaky wave radiation. The phasing of the radiating elements is such that the radiation pattern will be predominately end-fire toward the source feed point.

Among the advantages afforded by this invention are the following:

1. Two coupled lines are used instead of a single line, thus affording a greater flexibility in achieving various values of input impedance independent of other design parameters;

2. More types of resonant behavior of the radiating elements are permissible because energy can be coupled into the loaded line behind a stop-region which would reflect an incident wave;

3. Proper phasing for radiation is achieved without a feeder line or a radiating element transpose so that the structure may be imaged over a ground plane; and

4. The radiating elements themselves may be slots cut into the ground plane.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood from the following detailed description thereof taken in conjunction with the accompanying drawings in which:

FIGS. 1–4 are schematic diagrams illustrating several coupler configurations comprising alternating sections of coupled and uncoupled scaled lines in accordance with the principle of the present invention;

FIGS. 5–7 illustrate several log-periodic coupler fed arrays including radiating elements log-periodically scaled in the uncoupled sections of line;

FIG. 8 is a schematic diagram illustrating a log-periodic coupler fed slot array in accordance with the invention: and

FIG. 9 is an illustration of a strip transmission line embodiment in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present device includes the log-periodic scaling of conventional directional coupler elements to produce a wide-band coupler. When properly designed, the wide-band coupler will essentially couple all the energy from one of the coupled lines to the other. The energy is then radiated from a localized region in the second line. Several embodiments of the coupler of this invention are shown in FIGS. 1–4. The figures can best be understood by considering each line in the drawings as representing a transmission line, either a two wire line, a single line above a ground plane, or a strip transmission line. FIG. 1 shows a structure 20 composed of cascaded sections of alternating coupled lines 22 and uncoupled lines 24 of length ϕ_n and θ_n, respectively. Each cell of the structure is composed of a coupled and uncoupled section and is scaled from the adjacent larger cell by the scaling factor τ_1. That is $\theta_{n-1}=\tau_1\,\theta_n$ and $\phi_{n-1}=\phi_n\,\tau_1$. The electrical length of each section is the same in both lines and the mean impedances of the coupled and the connecting uncoupled line are the same, so that the input impedance when the structure is terminated in a matched impedance would be constant for all frequencies. In the bandwidth of a structure which is designed for essentially complete coupling, however, the terminations at the rear end become unimportant. The range of τ_1 to achieve essentially total coupling depends on the coupling coefficient of the coupling sections, as well as the relative length of ϕ_n to θ_n. Maximum coupling takes place when the total electrical length of both sides of a cell is approximately a wavelength. FIG. 2 is the same type of structure as FIG. 1, but in FIG. 2 the electrical lengths of the uncoupled sections 26,28 are different in each line. Total coupling can still be achieved and maximum coupling will still occur around the region where the composite electrical length of both sides of the cell is approximately a wavelength. FIG. 3 shows a structure 30 where the coupling sections 32, 34, etc. are interconnected by lengths of line and FIG. 4 shows a structure 40 where the coupling elements 42, 44, etc.

are directional couplers with opposite ports open circuited. All of these coupled lines produce wideband coupling. Each may have advantages for a particular application in terms of simplicity of construction or better performance for a particular frequency band of operation.

The effects of various resonant behaviors of the loading elements of the second line upon the coupling action and input impedance show that many more types of resonant behavior are permissible than with the conventional method of series or shunt feeding from a single line, while still achieving the desired pseudo-frequency independent behavior for antenna application. For example, it is possible to pass energy down one line and couple into what might normally be a lossy or radiating region between two stop-regions on the second line which is log-periodically loaded with radiating elements. This, of course, is not possible with the single line feed since the energy would normally be partially or totally stopped by any stop-region occurring ahead of the active elements.

Several embodiments of the invention employed as a log-periodically scaled directional coupler feed line in an antenna array are shown in FIGS. 5–7, where the radiating elements **50** are represented by square boxes and may be dipoles or folded dipoles in the two wire case. As indicated in FIG. 5(a), the radiating elements **50** are located in the parallel legs **24***a* and **24***b* of the uncoupled line section **24**. It must be realized that in accordance with this aspect of the invention, both the coupled regions **22** and uncoupled regions **24**, and the log-periodic radiating elements **50** are scaled. The antenna array shown in FIG. 5(a) is suitably fed from a source at the front end **52** of the antenna. FIG. 5(*b*) illustrates an embodiment of the two-wire aspect of this invention. As shown in FIG. 5(*b*), the two-wire lines are composed of coupled regions **22** and uncoupled regions **24**. The log-periodic scaled radiating elements (dipoles **50**) are suitably mounted in the uncoupled regions **24**, thus each of the lines in FIG. 5(*a*) has been constructed as two parallel wire lines in the aspect of this invention shown in FIG. 5(*b*). The antenna array is suitably fed from a source at the front end **52** of the antenna. In FIG. **6** the radiating elements **50** are log-periodically scaled within the uncoupled regions **54** between respective coupling elements **42**, **44**, etc. Similarly, in FIG. **7** the radiating elements **50** are suitably located in the uncoupled regions **56**, alternating with the coupled regions **58**.

When imaged over a ground plane so that each line represents a single line above ground, monopole or folded monopoles, or slots **60** cut in the ground plane **62** can be used, as shown in FIG. **8**. It is to be noted that the feed line **64** connected to the radiating slot elements **60** is not transposed to acquire the proper phase to radiate toward the source **67** and feed point **68**. The proper phasing has been achieved by changing the direction of the energy in the radiating part of the structure. The pseudo-frequency independent behavior is secured because of the scaling properties of both the coupler which scales the coupling region **70**, and the radiating slot elements **66** whose behavior scales on the radiating part of the structure at the uncoupled regions **66**. The feed line **72** is not connected to the radiating elements and is terminated at the front end of the array by a suitable impedance **74**. The rear end **76** of the antenna can be left open between lines **68** and **72**, assuming proper scaling of the coupled-uncoupled line sections and the radiating elements or if desired a suitable terminating impedance can be provided.

Reference may be made to FIG. **9** wherein there is illustrated a strip transmission line embodiment **80** according to the principals of the invention, wherein two microstrip lines **82** mounted on a dielectric substrate **84** are placed above a ground plane **86**, the lines **82** alternating in coupled and uncoupled sections **88**, **90** respectively. Radiating elements (monopoles **92**) are connected to one of the strip lines **82** as shown in FIG. **9**.

It is to be understood that the scaling from cell to cell of the structure does not have to be exactly log-periodic to obtain a working structure. As with the conventional log-periodic dipole array, variations in scaling and cell size are possible with corresponding somewhat inferior results, but for the widest band performance, the log-periodic scaling is the most desirable. Reference may be had to U.S. Pat. No. 3,210,767 issued Oct. 5, 1965, to D. E. Isbell, herein incorporated in its entirety, wherein such now well known log-periodic scaling is described in detail.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. A wide band antenna comprising:

a series of substantially log-periodically scaled radiating elements; and

feeder means coupled to said radiating elements, including a series of interconnected, alternating coupled and uncoupled substantially log-periodically scaled feeder sections extending outwardly from a feed point,

each of said feeder sections comprising two distinct transmission means,

said radiating elements coupled to only one of said transmission means at said uncoupled feeder sections; and

the other of said transmission means connected to said feed point.

2. A wide band antenna as claimed in claim **1**, wherein said feeder means comprises two two-wire transmission lines having closely coupled line sections alternating with and connected to relatively uncoupled line sections.

3. A wide band antenna as claimed in claim **2**, wherein the electrical lengths of said coupled and uncoupled line sections are defined by ϕ_n and θ_n, the electrical lengths of preceding coupled and uncoupled line sections toward said feed point being defined by ϕ_{n-1} and θ_{n-1}, respectively, and wherein each respective line section is scaled from the corresponding line section by a scaling factor, τ_1, where $\tau_1=\phi_{n-1}/\phi_n=\theta_{n-1}/\theta_n$.

4. A wide band antenna as claimed in claim **3**, wherein each succeeding radiating element is related to the preceding element by means of a scaling factor τ_2.

5. A wide band antenna as claimed in claim **1**, wherein said feeder means comprises two strip transmission lines having closely coupled line sections alternating with and connected to relatively uncoupled line sections.

6. A log-periodically scaled directional coupled feed line for feeding antenna elements comprising a series of interconnected, alternating coupled and uncoupled substantially log-periodically scaled feeder sections extending from a feed point, each of said feeder sections comprising two distinct transmission means, said antenna elements coupled to only one of said transmission means at said uncoupled feeder sections, and the other of said transmission means connected to said feed point.

7. A log-periodically scaled directional coupler feed line as claimed in claim **6**, wherein said feeder sections comprise two two-wire transmission lines having closely coupled line sections alternating with and connected to relatively uncoupled line sections.

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