

[54] RADIO SURFACE WAVE ANTENNA

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[51] Int. Cl. H01q 1/48
[58] Field of Search.....343/794, 822, 908, 719, 830, 343/833, 846

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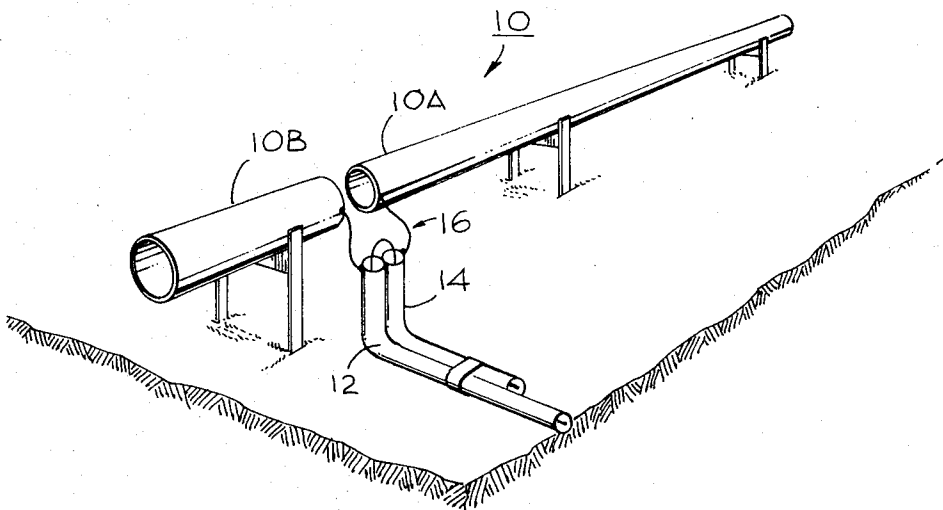
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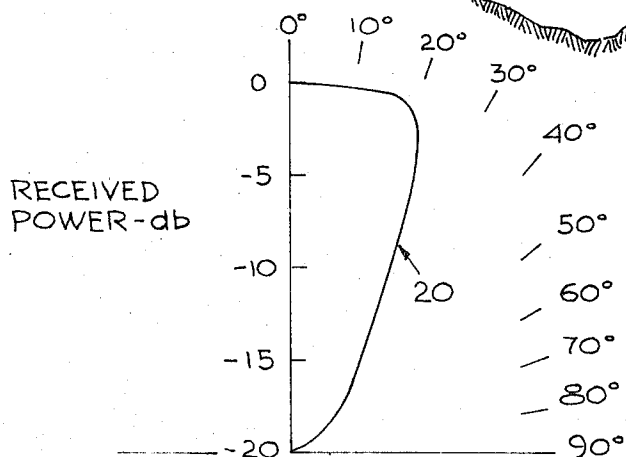
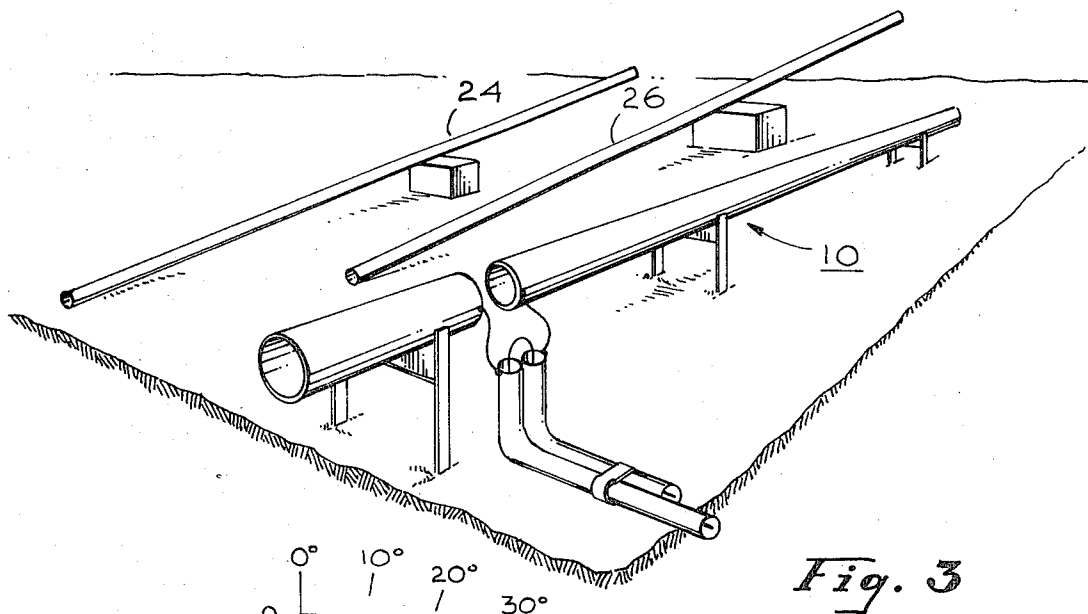
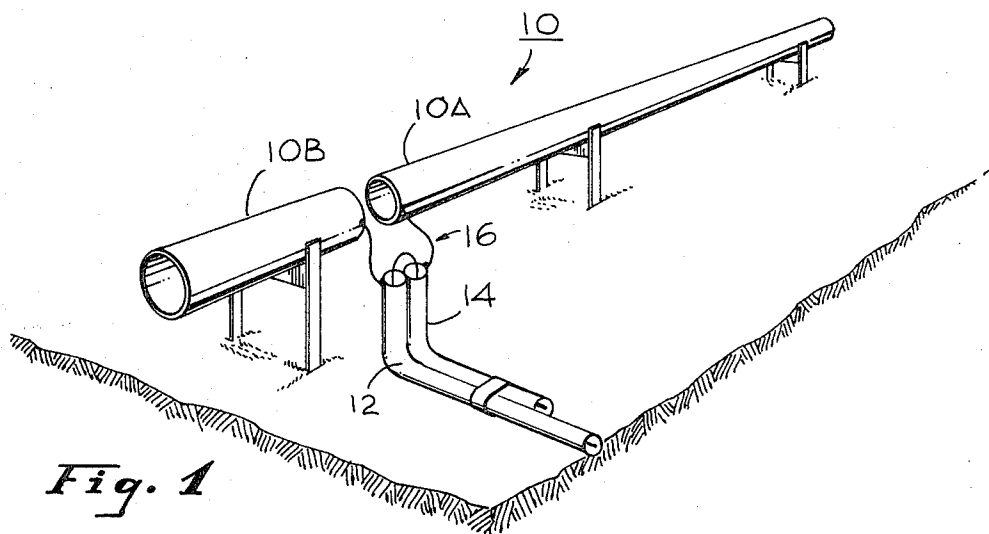
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[57] ABSTRACT

An antenna for radio surface waves may be constructed from a conductor such as a tube or a flat plate which is an even multiple of wavelengths long. There is a discontinuity or gap in the conductor about one-quarter wavelength from one end, which is on the order of one-fourth inch. The antenna is normally supported from 3 to 12 inches above the earth's surface and is excited longitudinally by a transverse electromagnetic mode (TEM) by connecting a source of excitation to the surface of the tube on both sides of the discontinuity, or to the surface of the flat plate on both sides of the discontinuity.

7 Claims, 5 Drawing Figures





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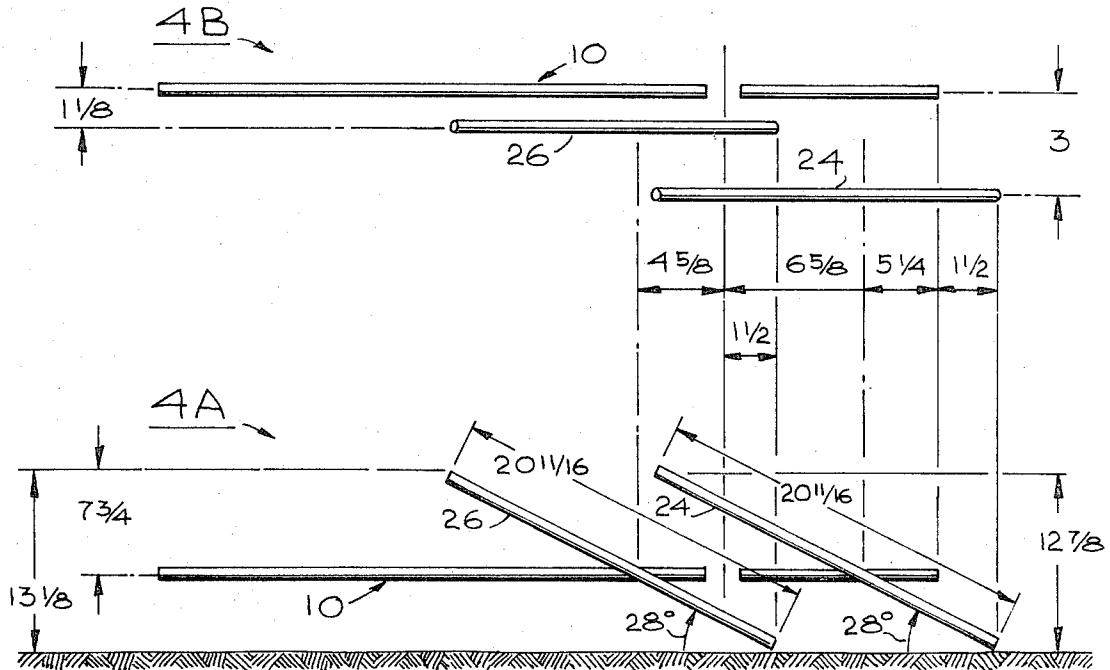


Fig. 4

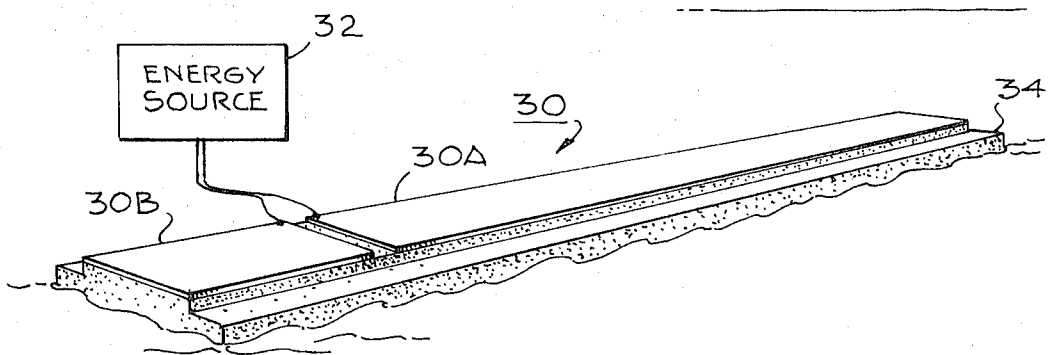


Fig. 5

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RADIO SURFACE WAVE ANTENNA

BACKGROUND OF THE INVENTION

This invention relates to surface wave antennas.

Radio surface waves have been discussed theoretically since the beginning of this century, but only in the last few decades have they been produced on dielectrically clad wires, corrugated conducting sheets and other specially prepared surfaces. Apparently these waves have not been deliberately produced and measured on the earth's surface, probably because of the lack of a suitable antenna or "wave launcher" for generating and receiving surface waves. Surface waves follow the surface of the earth and attenuate very rapidly with an increase in altitude above the surface. Thus, the use of surface waves is for communication over surfaces of the earth or ocean for surface wave radar, etc.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to produce a radio surface wave antenna.

This object is achieved by making a surface wave antenna which has the form of either a cylinder or a flat plate. It is made a number of wavelengths long, preferably two, and has a discontinuity or gap near one end. This discontinuity occurs approximately one-fourth wave length from one end and is on the order of one-fourth inch. Excitation is applied by connecting either a twin wire transmission line or a coaxial cable to the surfaces of the antenna at the discontinuity. The radiation which occurs from the antenna is an end fire radiation and produces TM planar surface waves.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric drawing of a surface wave antenna in accordance with this invention.

FIG. 2 shows a portion of the symmetric, bi-directional radiation pattern of a surface wave antenna as shown in FIG. 1.

FIG. 3 is an isometric view of the surface wave antenna together with parasitic reflectors in order to provide uni-directionality thereto.

FIG. 4 is a plane and profile view of the antenna and radiator arrangement shown in FIG. 3.

FIG. 5 shows a flat surface wave antenna, which is another embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there may be seen an isometric view of a ground wave launcher or antenna 10, in accordance with this invention. It consists of a tube which is made to have an even number of wavelengths in length to minimize broadside TEM radiation. The launcher, by way of illustration, is made two wavelengths long and is in two parts respectively 10A, with a spacing or discontinuity between the two. The part 10B is made about one-fourth wavelength. The spacing is not critical but is made on the order of one-fourth inch.

Excitation is accomplished by connecting the excitation source to the surface of the launcher on either side of the gap. Excitation here is shown as being from a coaxial cable 12 which is connected to a balun 14. Con-

nection is made from the coaxial cable and balun by means of a twin wire transmission line 16. Excitation can also take place from a coaxial cable only.

The reason why hollow tubing is employed is not because of necessity, but to save weight, since radiation occurs from the external surface of the tube.

By way of illustration of an operative embodiment, but not by way of limitation, a 100 MHz launcher was constructed of aluminum tubing 1 3/8 inch outer diameter. The tubing was made to be 18 feet, 8 inches long and was interrupted about 28 inches (one-fourth wavelength) from one end. In normal operation it is supported parallel to the earth's surface and about 3 to 12 inches thereabove. It is excited longitudinally from the transverse electronic mode on the transmission line.

A second launcher or antenna, similar to the one shown in FIG. 1 was constructed and used to measure first and received signal strength at various heights above the ground, then the radiation pattern of the launcher and finally to determine the variation of radiated power with range i.e., the propagation law. As was expected, the power received diminished with increasing height above the ground. There was an exponential decay of power with height which is typical of surface guided radio waves.

FIG. 2 shows the radiation pattern of the launcher obtained by rotating the receiving launcher in the horizontal plane. The launcher has a bi-directional, end fire, vertically polarized beam. The line 20, illustrates the pattern measured at a range of 173 feet. Both launchers were maintained at a height of 12 inches for these measurements. Another pair of launchers were built for use at 252 MHz which were somewhat less than half the size of those used for 100 MHz. Input impedance radiation pattern and variation of power with height above the earth's surface all prove to be similar to those measured at 100 MHz.

Repeated measurements of the propagation characteristics of the antenna show that at short ranges there is exponential propagation law followed at intermediate ranges by an increase of received power with increasing range and then finally at a very large region of 1/R³ propagation, where R is apparent range from transmitter to receiver.

The launcher can be made uni-directional by adding parasitic directors. As shown in the perspective view in FIG. 3, the parasitic elements respectively 24, 26 are displaced laterally from the tube, are inclined about 28° from the horizontal, and are about 4 percent longer than half a wavelength in air.

FIG. 4A is a profile view of the wave launcher and the parasitic directors in FIG. 4B is a plan view thereof. These are shown together with illustrative dimensions for a 252 MHz wave launcher. One-half inch OD aluminum tubing was employed. The dimensions shown are in inches. Again, the figures given are illustrative and not restrictive.

When unidirectional launchers are used for both transmitting and receiving, there is increased directivity and a corresponding 6 DB increase in gain. The front to back ratio in the radiation pattern of a unidirectional launcher is 27 DB for the arrangement shown.

Measurements were made over salt water as well as on dry land. It was found that over salt water the elec-

electromagnetic field clings more closely to the surface; that is, there is a more rapid attenuation with increasing height. It was found that there was a decrease in signal with increasing height on the order of 5 to 10 DB per foot whereas measurements over a wet clay field, for example, to show a decrease with height of only 3 DB per foot.

It was also found that the length of the launcher is less critical when used over salt water than over a wet clay soil; that is, the launcher is a broad band device.

Since the electromagnetic field clings so closely to a surface it was believed to be advantageous to increase the surface area of the launcher. Accordingly, the tubular elements of both the transmitting and receiving launchers were replaced by flat horizontal aluminum sheets and an increase in received power of 15 to 20 DB was obtained during operation over salt water. The flat launcher, dimensionally follows the same rules as a cylindrical launcher, except that the width was made on the order to 12 inches, by way of example. A perspective view is shown in FIG. 5 wherein the flat launcher 30 consists of the two parts 30A, 30B, wherein 30B is sized on the order of one-fourth wavelength. The spacing between 30A and 30B is on the order of one-fourth inch. An energy source 32 excites the flat launcher through a twin lead transmission line similar to the manner of excitation of the cylindrical launcher. The launcher is placed a few inches above the surface 34 over which it is to be launched. This surface may be either earth or water.

There has accordingly been shown and described above a novel, useful radio surface wave launcher.

What is claimed is:

1. A radio surface wave launcher comprising: a conductive surface having an overall length on the order of an even multiple of a number of wavelengths at the frequency desired for transmitting radio surface waves, there being a gap in said conductive surface at a distance from one end of said conductive surface on the order of one-quarter wavelength of the frequency of said radio surface waves,
 - means for insulatingly supporting said entire conductive surface above and substantially parallel to the surface of the earth, and
 - means for applying radio surface wave excitation to said conductive surface on either side of said gap.
2. A radio surface wave launcher as recited in claim

1 wherein said conductive surface is a cylindrical surface.

3. A surface wave launcher as recited in claim 1 wherein said conductive surface is a flat surface.

4. A radio surface wave launcher as recited in claim 1 wherein there are included parasitic elements comprising a second and a third conductive surface placed adjacent the gap in said launcher conductor surface, parallel to said launcher and at an angle to earth.

5. A radio surface wave launcher comprising: a conductor cylinder having a length on the order of two wavelengths at the frequency at which said radio surface wave launcher is to be operated, and having a discontinuity at substantially one-quarter wavelength from one end thereof,

- means for insulatingly supporting said entire conductive cylinder above and substantially parallel to the earth, and
- means for energizing said radio surface wave launcher connected thereto at either side of said discontinuity.

6. A radio surface wave launcher as recited in claim 5 wherein there is included parasitic directors comprising:

a first and second cylindrical conductor body positioned adjacent said radio surface wave launcher at the location of the gap therein, parallel thereto and spaced therefrom, one of said two cylindrical conductors being inclined upwards from the ground at an angle commencing from a point behind said radio surface wave launcher, the other conductive body being inclined upward from the ground at the same angle and from a location adjacent the gap of said radio surface wave launcher.

7. A radio surface wave launcher comprising: a flat rectangular conductive sheet having a length on the order of two wavelengths of the frequency at which it is desired to launch said radio surface waves, said sheet having a gap at a location which is substantially one-quarter wavelength at said excitation frequency from one end thereof,

- means for supporting said entire flat rectangular sheet insulatingly above and substantially parallel to the surface of the earth, and
- means for applying the desired excitation to said radio surface wave launcher on either side of said gap.

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