

Nov. 30, 1965

E. SPITZ

3,221,331

LEAKY SURFACE-WAVE ANTENNA WITH DISTRIBUTED EXCITATION

Filed Dec. 13, 1962

3 Sheets-Sheet 1

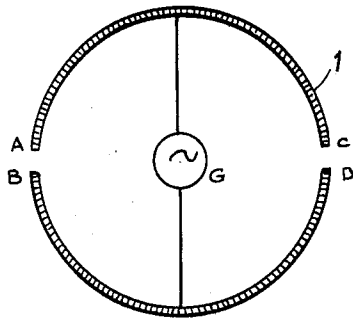


Fig:1

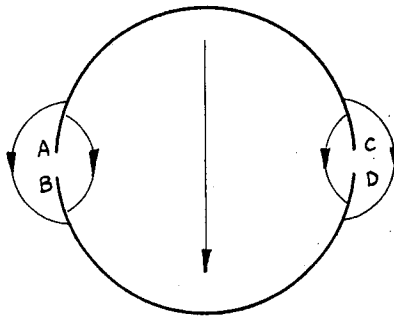


Fig:2

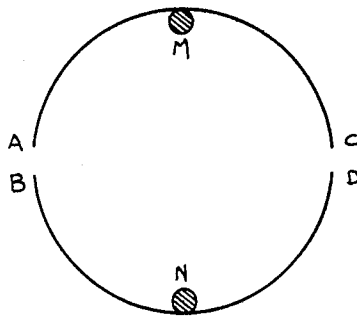


Fig:3

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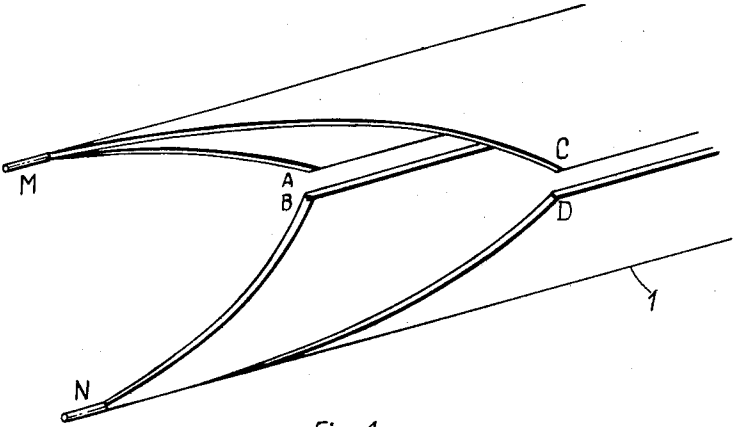


Fig: 4

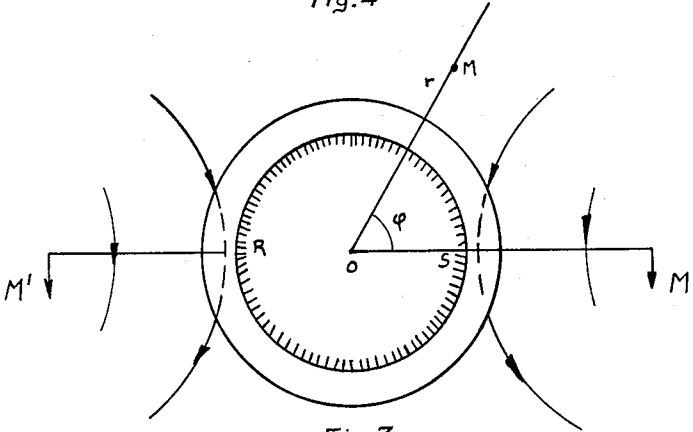


Fig: 7

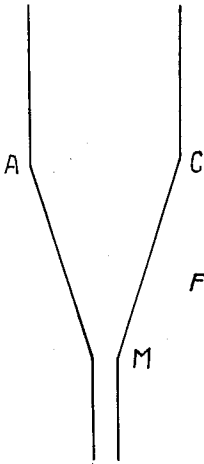


Fig: 5

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3 Sheets-Sheet 3

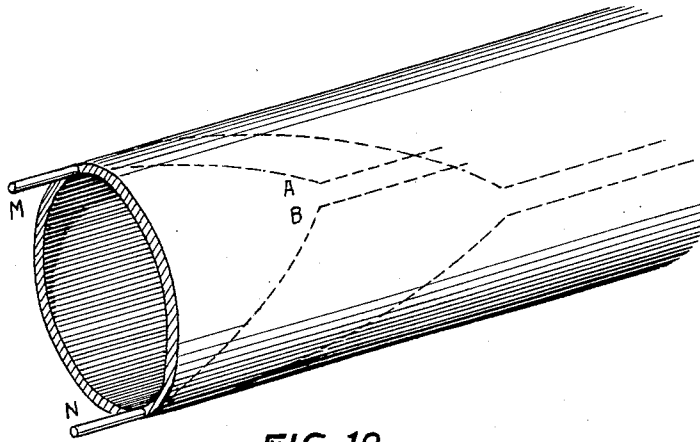


FIG. 10

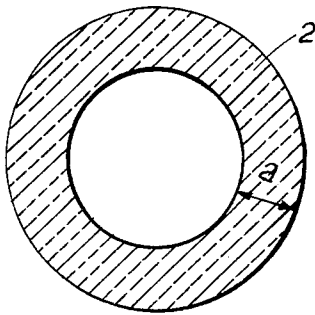


FIG. 6

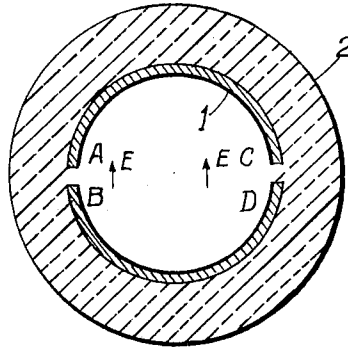


FIG. 8

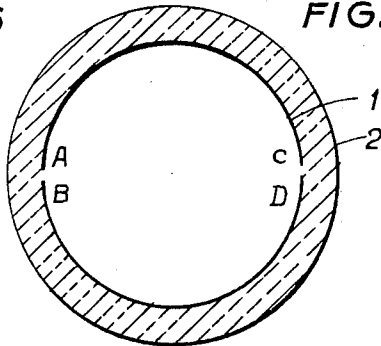


FIG. 9

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LEAKY SURFACE-WAVE ANTENNA WITH DISTRIBUTED EXCITATION

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883,416, Patent 1,317,337

8 Claims. (Cl. 343—785)

The present invention relates to antennas with distributed excitation.

The antennas of this type generally comprise two propagation lines coupled to each other and wherein propagation takes place in parallel directions. One is the excitation line; it is non dissipative and is coupled to an ultra-high frequency energy generator.

The other line is the radiating line and receives the energy from the excitation line all over its length and radiates it in the surrounding free space.

It is an object of the invention to provide an antenna with distributed excitation wherein the radiation diagram is of revolution about the direction of maximum radiation.

An antenna according to the invention comprises an excitation line including two metallic, semi-cylindrical portions of the same diameter, facing each other, separated by two gaps and brought to ultra-high frequency potentials in phase opposition, for example by means of a bifilar line; the radiating line comprises a sleeve of dielectric material which surrounds the excitation line and is in contact therewith.

The invention will be best understood from the following description and appended drawings, wherein:

FIG. 1 is a cross-sectional view of the exciter line;

FIG. 2 shows the pattern of the electric field in the line of FIG. 1;

FIGS. 3, 4 and 5 show respectively an end view, a perspective view and a top view of the exciter system;

FIG. 6 shows diagrammatically an end view of the radiating line;

FIG. 7 is an explanatory diagram;

FIG. 8 shows by way of example an embodiment of a system according to the invention; and

FIGS. 9 and 10 are, respectively, a cross-sectional and a perspective view of a further embodiment of the invention.

FIG. 1 shows an exciter line 1 which is formed as a cylindrical conducting tube allotted along two generatrices, symmetrical with respect to the axis of the tube.

Portions AC and BD of the tube are brought to A.C. potentials in phase opposition, for example by means of an A.C. voltage source, such as a generator C.

The diameter of the tube is, for example, of the order of one third of the operating wave-length λ .

The width of the gaps AB and CD controls the coupling between the exciter and the radiating lines. It also determines the characteristic impedance of line 1. This width is not critical, but has to be very small as compared to the operating wave-length λ , say, for example, of the order of $\lambda/10$, if it is desired that the length l of the line be of the order of 10λ .

The electric field both inside and outside tube 1 is that of a TEM-wave. The electric field presents the same pattern as that of the static field of two conductors AC and BD brought to different potentials. It is higher in gaps AB and CD and is in phase in the gaps in the same cross-section of the tube. As may be seen, the exciter line 1 is symmetrical with respect to a diametral plane, perpendicular to the plane of the gaps. Also, its characteristic

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impedance is rather high. Accordingly, it is better to couple this line to a symmetrical, bifilar line rather than to a coaxial line. In the nonlimitative embodiment shown, it is in the prolongation of the exciter line and is located in the diametral plane thereof which is normal to the plane comprising the gaps, as shown in FIG. 3. The two wires M and N are normal to the plane of the figure.

This arrangement is shown in end-view, in FIG. 3.

In FIG. 4, there is shown a perspective view of an exciter line according to the invention comprising wires M and N and cylinder 1. Line 1 is connected to wires M and N by means of two tapered terminal portions MAB and NBD of cylinder 1. FIG. 5 represents the same assembly, as seen from the top. Line 1 cannot radiate substantial energy if there is no outer dielectric coating.

The radiating line 2 shown in FIG. 6 is in the shape of a cylindrical sleeve made of an insulating material. The inner radius is substantially that of cylinder 1. Everything happens as if its central portion of this hollow dielectric wave guide were filled with a conductive body. The lowest mode propagated by this dielectric sleeve is a hybrid one, comprising axial components of both E and H. As this hybrid mode is the counterpart of the dominant TE_{11} existing in a metal circular pipe, it will be labeled HEM_{11} .

According to the invention, this line is excited so as to have an endfire radiation pattern. It is therefore necessary to propagate energy in such a manner that the electric fields at points M and M' of the same diameter of a cross-section and in symmetric relationship with respect to the center O thereof, may be in phase. Moreover, and in order that a coupling may exist between lines 1 and 2, the velocity of the surface wave guided by the cylindrical sleeve 2, should be that of the light, this being the velocity of the TEM-waves in line 1.

Only a HEM_{11} -mode, such as that of which the lines of force of the electric field are shown in FIG. 7, satisfies this requirement: it may be shown that, if the thickness e of the dielectric of sleeve 2 is small, the velocity v of mode HEM_{11} differs from the light velocity, by a term in e^2 .

Satisfactory results are obtained if e is selected to have a value of the order of $\lambda/20$.

Under such conditions, line 1 may be used to excite line 2. Since the propagation velocities are the same, it will suffice to arrange them in a suitable manner.

FIG. 8 shows a first embodiment of the invention. The outer diameter of the two semi-cylindrical portions AC and BD, building up line 1, is equal to the inner diameter of sleeve 2 into which they are tightly fitted. It should be noted that the electric fields E being in phase in the gaps AB and CD, mode HEM_{11} will be excited in line 2. Moreover, the ultra-high frequency energy being concentrated in these gaps, the coupling will be excellent. It will depend on the width of the gap, which is of the order of $\lambda/10$.

It should be noted that the HEM_{11} mode having zero cut-off frequency, energy will propagate whatever the frequency of the excited wave.

FIG. 9 shows in cross-section another embodiment of the invention a perspective view of which is shown in FIG. 10. In this case, line 1 is built up by a metal deposit on the inner wall of sleeve 2. This deposit is interrupted between two pairs of generatrices to build up gaps AB and CD. The sleeve is made, for example, of a dielectric material with $\epsilon=4$, such as for example the material known under the registered trademark Silirite. Its thickness e is $\lambda/20$.

Wires M and N are soldered, as shown in FIG. 9, to the inner metal deposit. They may be located in slots formed

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in the dielectric sleeve the assembly being thus shaped as a smooth rigid tube.

Wave HEM₁₁ being symmetrical with respect to the axis of the cylinder and with the free field velocity the antenna radiates towards the end thereof: it is an end-fire antenna.

An antenna according to the invention presents the following advantages:

(a) The radiation pattern is of revolution about the axis, thus being of the end-fire type.

(b) While having a simple structure, similar to that of the so-called Goubau-lines, it provides an easy way of radiating the surface wave propagating along it.

(c) It is fed by a bifilar line and the exciter line does not require more room than the radiating line, what is generally not the case in conventional end-fire antennas.

(d) The antenna does not comprise any element, having a high quality factor and may be operated within a wide frequency band, say of the order of one octave.

What is claimed is:

1. An antenna for radiating ultra-high frequency wave energy, comprising: an excitation line including two metallic symmetrical bodies, shaped as portions of a cylinder and separated by two gaps, and means for bringing said bodies to ultra-high frequency potentials in phase opposition; and a radiating line comprising a sleeve of dielectric material surrounding said bodies and in contact therewith.

2. An antenna for radiating ultra-high frequency wave energy, comprising: an excitation line including two metallic symmetrical bodies, shaped as portions of a cylinder and separated by two gaps, and means for bringing said bodies to ultra-high frequency potentials in phase opposition; a radiating line comprising a sleeve of dielectric material surrounding said bodies and in contact therewith; said bodies having respective terminal symmetrical tapered portions; and a symmetrical line including two conductors respectively coupled to said tapered portions.

3. An antenna for radiating ultra-high frequency wave energy, comprising: an excitation line including two metallic symmetrical semi-cylindrical portions, facing each other along two generatrices thereof and separated by two gaps, and means for bringing said portions to ultra-high frequency potentials in phase opposition; and a radiating line comprising a sleeve of dielectric material surrounding said portions and in contact therewith.

4. An antenna for radiating ultra-high frequency wave energy, comprising: an excitation line including two metallic symmetrical semi-cylindrical portions, facing each other along two generatrices thereof and separated by two gaps, and means for bringing said portions to ultra-high frequency potentials in phase opposition; a radiating line comprising a sleeve of dielectric material surrounding said portions and in contact therewith; said semicylindrical portions having respectively terminals symmetrical, tapered

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projections and a symmetrical line, including two conductors respectively coupled to said projections.

5. An antenna for radiating ultra-high frequency wave energy, comprising: an excitation line including two metallic symmetrical bodies shaped as portions of a cylinder and separated by two gaps, and means for bringing said bodies to ultra-high frequency potentials in phase opposition; a radiating line comprising a sleeve of dielectric material surrounding said bodies and in contact therewith; and a two wire transmission line, having two symmetrical conductors respectively connected to said portions.

6. An antenna for radiating ultra-high frequency wave energy, comprising: an excitation line including two metallic symmetrical semi-cylindrical portions, facing each other along two generatrices thereof and separated by two gaps, and means for bringing said portions to ultra-high frequency potentials in phase opposition; a radiating line comprising a sleeve of dielectric material surrounding said portions and in contact therewith; and a two wire transmission line, having two symmetrical conductors respectively connected to said portions.

7. An antenna for radiating ultra-high frequency wave energy, comprising: a radiating line in the shape of a sleeve of dielectric material having an inner wall; an excitation line including two metal symmetrical layers, shaped as portions of a cylinder separated by two gaps and deposited on said inner wall; and means for bringing said layers to ultra-high frequency potentials in phase opposition.

8. An antenna for radiating ultra-high frequency wave energy, comprising: a radiating line in the shape of a sleeve of dielectric material, having an inner wall; an excitation line including two metal symmetrical semi-cylindrical layers, facing each other along two generatrices thereof, separated by two gaps and deposited on said inner wall; and means for bringing said layers to ultra-high frequency potentials in phase opposition.

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