United States Patent

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Continuation-in-part of application Ser. No. 587,611, Oct. 18, 1966, now abandoned.

[54] ATTACHMENT OF SURFACE WAVE LAUNCHER AND SURFACE WAVE CONDUCTOR

6 Claims, 7 Drawing Figs.

[52] U.S. Cl. 333/21, 333/95, 333/98, 343/785
[51] Int. Cl. H01p 1/16, H01p 3/10, H01q 13/06
[50] Field of Search 343/785; 333/95 (S), 95

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ABSTRACT: The invention essentially consists of providing a substantially continuous transition of the wave of the launcher to the wave of the line by surrounding the line when emerging from the launcher with a preferably lowloss dielectric of relatively large diameter corresponding to the diameter of the launcher, which is gradually decreased while extending over the line of the diameter of the dielectric coating of the line itself.

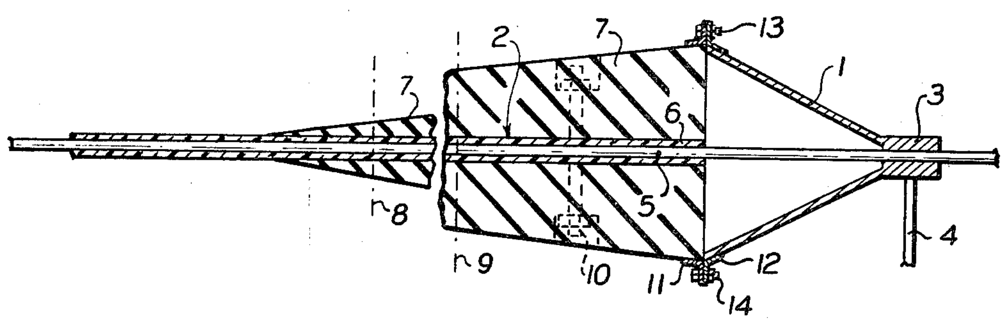


FIG. 1.

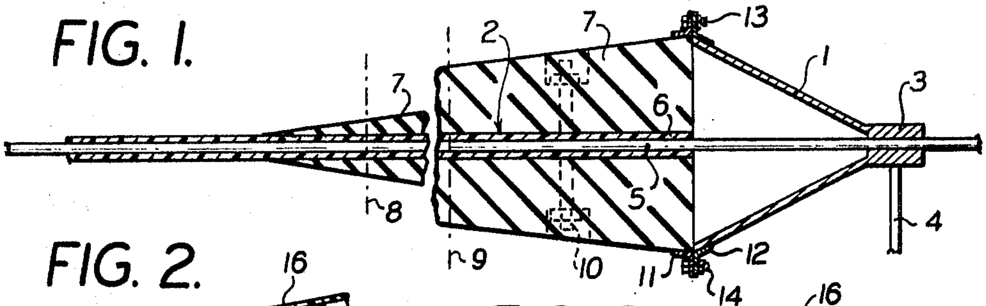


FIG. 2.

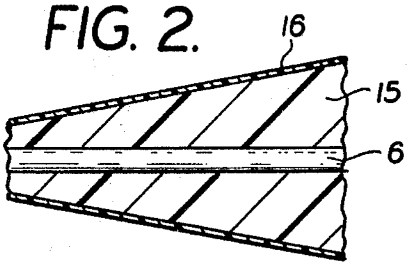


FIG. 3.

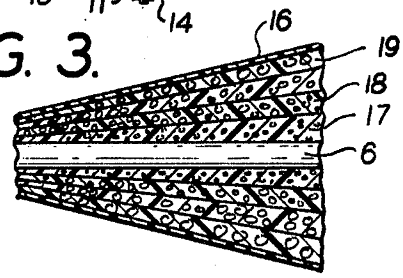


FIG. 4.

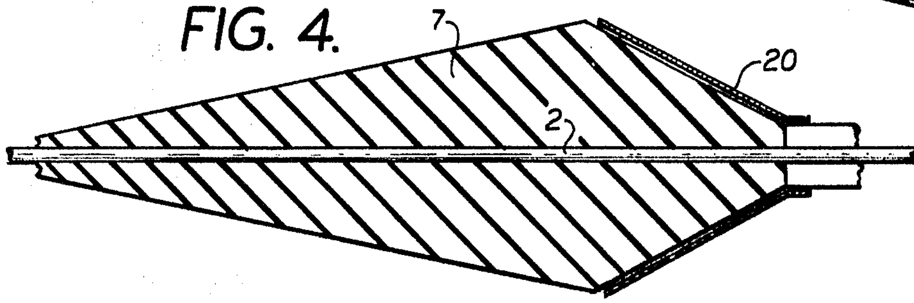


FIG. 5.

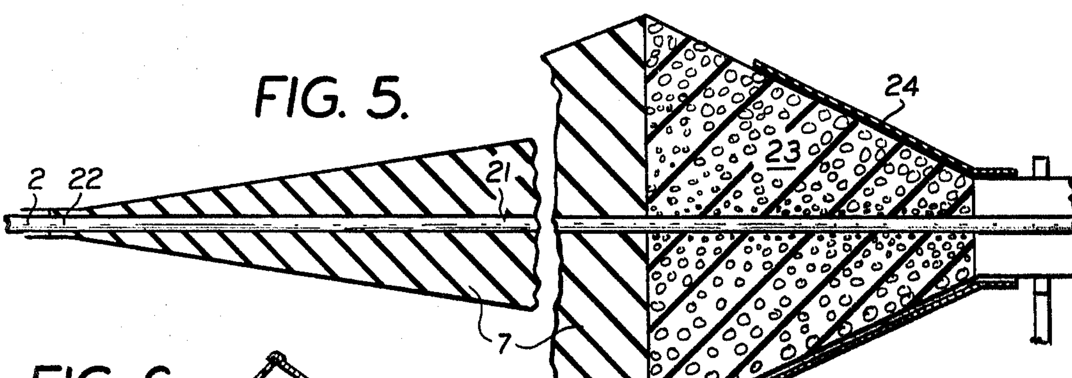


FIG. 6.

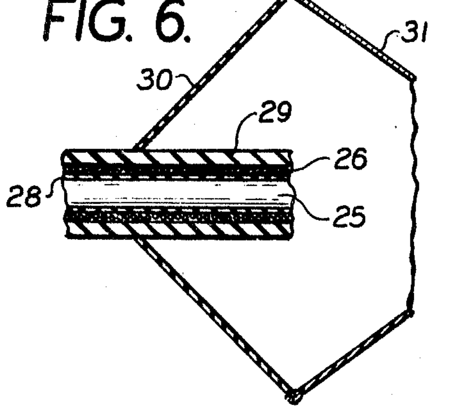
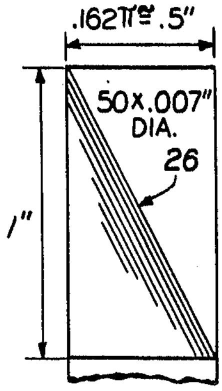


FIG. 7.



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ATTACHMENT OF SURFACE WAVE LAUNCHER AND SURFACE WAVE CONDUCTOR

This invention relates to the production or launching and receiving of surface waves. It is a continuation in part of SN.587,611, filed Oct. 18, 1966, now abandoned.

One of the objects of the invention is to increase the efficiency of the launching or receiving of the surface wave, and especially of reducing radiation to a minimum at launching and reception, respectively.

Another object of the invention is to better secure the launcher or receiver in its position with respect to the line and, more specifically, to make it better ride on the line with a minimum of relative displacements or vibrations occurring between line and launchers or receivers.

These and other objects of the invention will be more fully apparent from the drawings annexed herein, in which

FIG. 1 illustrates an example of the invention as applied to a usual type of surface wave launcher, and FIG. 2 and 3 modifications.

FIG. 4 shows another embodiment of the invention as applied to another type of launcher, and FIG. 5 another modification.

FIG. 6 shows a specific type of conductor, used in another embodiment of the invention.

FIG. 7 specifies a particularly structured line or cable which may be used in another realization of the invention.

In FIG. 1, part 1 illustrates the horn or launching (or receiving) end of a surface wave launcher (or receiver) as described for example in Ser. No. 473,035 where it is shown to be used for surface wave transmission over a line forming part of a high-voltage distribution system, and which in FIG. 1 is diagrammatically indicated at 2. Horn 1 is connected in otherwise well known manner with a transducer schematically shown at 3 to a coaxial cable 4 leading to the terminal equipment (transmitter, receiver, antenna etc.) not shown. Line 2, generally consists of a conductor 5 surrounded by a lowloss dielectric coating 6 of sufficient thickness to concentrate the wave emerging from horn 1 to a diameter corresponding to the diameter of the wave emerging from the horn. However, since the dimensions of the horns for mechanical reasons are limited especially at relatively low frequencies for example in the VHF or commercial TV range, and correspondingly high wave lengths, the diameter of the wave emerging from horn 1 will somewhat differ from the diameter of the wave as determined by the surface wave transmission line to which it is connected, and as a result of this difference, there will be a loss in the transition of horn wave to wire wave, which does not only reduce the efficiency of launching and receiving, but also give rise to radiation which is generally undesirable since the surface wave transmission line is of essentially nonradiating character, and especially in the TV or VHF range, is used as a lowloss nonradiation transmission line replacing coaxial cable and microwave relays.

In accordance with one feature of the invention a transition between launcher wave and line wave, will be created, by arranging a dielectric schematically indicated at 7, extending from the mouth of horn 1 over a distance corresponding to several wavelengths of the operating wavelength of the surface wave transmission line, over line 2, decreasing in diameter until it reaches the outer diameter of dielectric coating 6 of line 2.

Dielectric 7 may be preformed in several radial and/or axial sections, which may be attached together either by gluing or mechanically, by dielectric bolts and screws schematically indicated by axes **8**, **9**, and **10**, and actually indicated in dotted lines consisting for example of nylon or other relatively lowloss dielectric material of comparatively high mechanical strength.

Instead of bolt and screw attachments, dielectric tape may be used to hold the different sectors or segments of dielectric mass 7 together without substantially increasing the loss of the surface wave traveling from horn 1 to and over line 2.

Dielectric body 7 is also attached to horn 1 peripherally, for example by metal rings 11, 12 surrounding and attached to body 7 and horn 1 peripherally, and attached to each other by screws schematically at 13, 14, regularly distributed over the periphery of horn 1 and body 7 so as to make horn 1 and body 7 together with line 2, a more or less unitary structure, with sufficient elasticity, however, so as to permit riding such structure on line 2 at different angles of line 2 and under different vibratory conditions such as may occur on open wire lines as a result of varying outdoor conditions.

Dielectric body 7 may be of the same material as the coating 6 of line 2, for example high density polyethylene of loss factor which is low at the operating frequencies concerned.

It may also be made of different material, for example of a minimum loss material at the core, such as pure polyethylene, as shown in the modification of FIG. 2, at 15, which is surrounded with a relatively high-loss but weather protective coating or skin 16.

Also without exceeding the scope of this disclosure, dielectric 6 of line 2 itself may be made part of dielectric body 7, and a body 7 thus modified be attached directly on conductor 5.

Furthermore, as another modification of the invention, dielectric body 7 may be constructed in a stratified manner, for example as shown in FIG. 3, consisting of a number of strata of dielectric material, schematically indicated in FIG. 3, at 17, 18 and 19, gradually decreasing in density when approaching the periphery or surface of body 7; thus it may become more and more foamy when approaching this periphery, at which it is surrounded as shown in FIG. 2, by a weatherproof coating as indicated at 16.

Without exceeding the scope of this disclosure, instead of constructing body 7 of several distinct strata, or layers of different dielectric structure, it may be composed of continuous structure of gradually varying foaminess from the center to the periphery.

In the modification shown in FIG. 4, the dielectric body shown in the preceding FIGS. at 7, is shown to extend into the interior of horns 2 which will increase the solidity of elements, as a unitary structure. In this case the horn can be formed simply as a metallic foil or coating schematically indicated in FIG. 4 at 20, thus reducing weight and also cost, without impairing function and efficiency of the launcher system as a whole.

In a further modification of the invention, illustrated in FIG. 5, dielectric body 7, may be structurally combined with line 2, on which it is supported, and also if desired in combination with horn configuration shown in FIG. 4, it may be made a structural unit with line 2 at least to the extent in which line 2 is surrounded by body 7. In this case conductor 5 of line 2 may be incorporated as core of body 7 which will be manufactured by being moulded around conductor 5, or at least that portion indicated in FIG. 5 at 21. For mounting, therefore, body 7 supporting both horn 2 and conductor part 21, can be applied as unit and by simply attaching and connecting the end portion 22 of conductor 21, to the surface wave transmission line proper as indicated in FIG. 5 at 2, the transmission line system can be constructed with a minimum of work to be performed outdoors, or on the masts or poles which are to carry the system.

In another modification also indicated in FIG. 5, the dielectric body 7 may be stratified in a direction parallel to its axis; thus conical part 23 inside horn 24, may be made of foam approximating the inner loss to that of air, or to a minimum.

While the invention has been described and illustrated with respect to certain launching and receiving, as well as transmitting means for surface waves, it is not limited thereto; it may be applied with other such means, and with different dielectrics and dielectric and conducting structures, all this without departing from the scope of this disclosure.

Thus in a further embodiment of the invention, and in order to increase the flexibility of the entire horn-line combination, especially under all possible outdoor operation conditions, the flexibility of the line is increased, while maintaining or, if possible, also increasing its mechanical or breaking strength. Generally, flexibility and breaking strength, are considered to be properties which at least to some extent oppose each other; while one may be increased, frequently the other will be decreased.

In accordance with this aspect of the invention, and as illustrated in FIG. 6, a surface wave transmission line such as shown at **2**, **22** or **23**, or generally any surface wave transmission line, is made to consist of a core **25** contributing maximum mechanical strength and maximum mechanical flexibility to the structure, without substantially contributing to its effect as a surface wave conductor; core **25** which consists of high strength steel rope, or plastic rope such as high strength Nypon, Dacron, Polyester, or any mixture of plastic materials, or steel and plastic materials of high flexibility, is surrounded by a layer of conducting material which is also of high strength as well as of high flexibility. In accordance with the invention, this conducting layer as indicated in FIG. 6, schematically at **26**, consists of high strength copper wire, or copperplated steel wire, or copperplated aluminum wire, which is wound around core **25** spirally and in a number of parallel spirals or helices of rather steep inclination, at least 45° with respect to the axis or the generatrix of the cylinder constituting core **25**, in order to reduce the path of the VHF frequency currents passing along layer **26**, and thereby the conductive loss, to a minimum.

FIG. 7 represents such spirals at **26**, developed in a plane, whereby the outer diameter of the underlying core, or core portions, is of 0.162 corresponding to a 06 cable, and the height of each convolution is twice the width of the developed surface, i.e. about 1 inch. The spirals **26** themselves consist of 50 copper-, or silver-coated steel wires of about 0.007 inch diameter, and arranged parallely in a single layer surrounding cone **25**.

In this way, with a minimum of expensive material, and a maximum of VHF surface conductivity, optimum flexibility and strength conditions are maintained.

If required, and without departing from the scope of this disclosure, conducting layer **26** can be separated from the underlying core **25**, by an electrically insulating layer schematically indicated in FIG. 6 at **28**, thus permitting DC or low frequency AC current to be applied to the cable, for the purpose of heating the cable under ice or sleet conditions, or for any other utility or control purpose.

Otherwise, conducting layer **26**, is surrounded by a dielectric **29**, a coating or moulding such as indicated in any of the preceding FIGS., or in any other way, to permit the maintaining of a surface wave derived from dielectric **30**, and a launcher **31**, as shown in any of the preceding FIGS., or by any other surface wave launcher or receiver.

While the above embodiments of the invention have been described or illustrated by way of specifying certain conducting or insulating materials, certain dimensions, and certain arrangements in space of such elements, or dimensions, the invention is not limited thereto and may be applied in any appropriate way to conform with its functions without departing from the scope of this disclosure.

I claim:

1. In a surface wave transmission system, means including a horn-type launcher and a surface wave transmission line connected thereto, for for producing and maintaining at least one surface wave around the line within a predetermined operation frequency range, and dielectric means attached to, and

extending from the outer edge of said launcher over said line gradually decreasing in diameter until the diameter of said line is reached, thereby causing the wave of the launcher to gradually transgress into the wave of the line while assuring concentricity between launcher and line, said dielectric having a layer-type structure, the material arranged closer to the edge to which it is attached, being relatively less dense than that arranged closer to the line.

2. System according to claim **1**, wherein said line includes a core which is relatively nonconducting at said frequency range, and which is of high flexibility and high tensile strength, said core being surrounded by at least one layer of high conductivity at said frequency range, and of high flexibility but of low tensile strength, said layer consisting of a number of parallel conductors spirally wound around said core, and a dielectric coating surrounding said layer for producing with said layer surface waves within said frequency range.

3. System according to claim **1**, wherein said line includes a core which is relatively nonconducting at said frequency range, and which is of high flexibility and high tensile strength, said cure being surrounded by at least one layer of high conductivity at said frequency range, and of high flexibility but of low tensile strength, said layer consisting of a number of parallel conductors wound around said core, and a dielectric coating surrounding said layer for producing with said layer surface waves within said frequency range, said parallel conductors being spirally wound with an inclination of at least 45° with respect to the generatrix of the core surface.

4. System according to claim **1**, wherein said line includes a core which is relatively nonconducting at said frequency range, and which is of high flexibility and high tensile strength, said core being surrounded by at least one layer of high conductivity at said frequency range, and of high flexibility but of low tensile strength, said layer consisting of a number of conductors wound around said core, and a dielectric coating surrounding said layer for producing surface waves within said frequency range, and wherein said conductors consist of copper-coated steel wire which is additionally silver coated.

5. System according to claim **1**, wherein said line includes a core which is relatively nonconducting at said frequency range, and which is of high flexibility and high tensile strength, said core being surrounded by at least one layer of high conductivity at said frequency range, and of high flexibility but of low tensile strength, said layer consisting of a number of conductors wound around said core, and a dielectric coating surrounding said layer for maintaining surface waves within said frequency range, and wherein said core consists of plastic rope.

6. System according to claim **1**, wherein said line includes a core which is relatively nonconducting at said frequency range, and which is of high flexibility and high tensile strength, said core being surrounded by at least one layer of high conductivity at said frequency range, and of high flexibility but of low tensile strength, said layer consisting of a number of conductors wound around said core, and a dielectric coating surrounding said layer for maintaining surface waves within said frequency range, there being provided an additional dielectric layer between said core and said conducting layer for low frequency conduction between said core and said conducting layer.