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2,841,791

HIGH DIELECTRIC TYPE ANTENNA

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Fig. 1

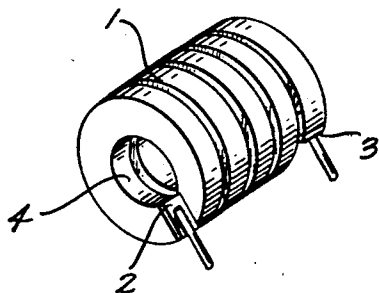


Fig. 2

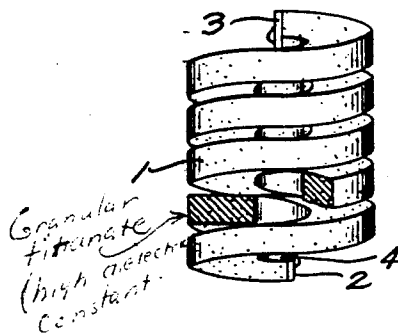


Fig. 4

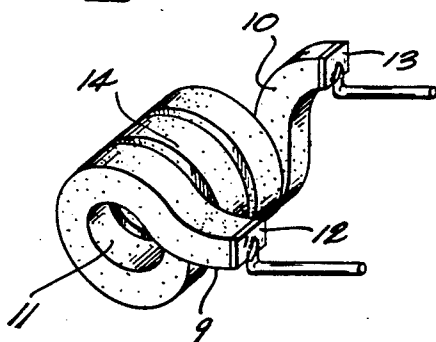


Fig. 3

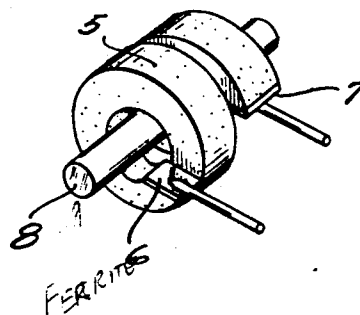
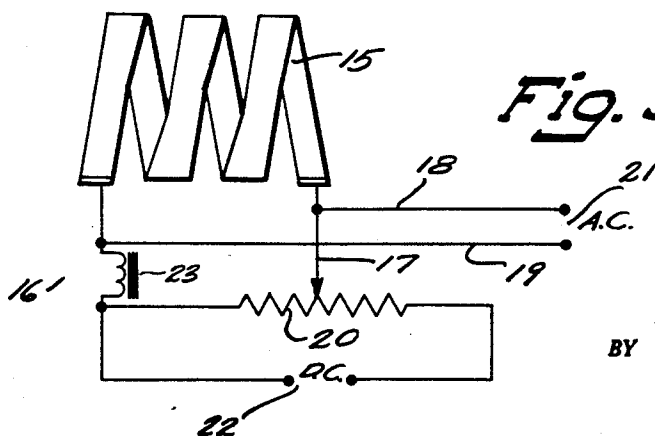


Fig. 5



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1

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HIGH DIELECTRIC TYPE ANTENNA

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3 Claims. (Cl. 343-787)

This invention relates to apparatus for directing alternating electric currents in helical paths without resort to metallic conducting windings, and it resides more specifically in a novel helical body of dielectric substance having bare side surfaces and a dielectric constant in excess of 50 and preferably in excess of 1000, the body having means for excitation associated therewith adapted to be included in a driving circuit.

Alternating currents, particularly in the upper frequency ranges, have heretofore been caused to flow in helical paths, by providing coils or windings of substances having the property of metallic conduction. It has been necessary, in many such instances, to employ tuning capacitors in conjunction with the metallic coils which restricts the same to the handling of comparatively narrow bands of frequencies.

It is the discovery of this invention that a dielectric substance, having a dielectric constant in excess of 50, may be formed as a helix of one or more turns with bare side surfaces, the ends of which may be electrically excited by alternating current which will flow in said helix with little loss. The helical alternating current flow, carried by displacement currents in the apparatus of this invention, is handled without the close restriction to tuned frequencies above noted and comparatively broad-bands of frequencies will be conducted effectively.

For certain purposes the broad-band properties of the helix of this invention are of special utility as for example, where a magnetic dipole antenna with broad-band properties is desired.

This invention is herein described by reference to the accompanying drawing forming a part hereof wherein there is set forth by way of illustration and not of limitation specific forms in which the apparatus of this invention may be embodied.

In the drawing:

Fig. 1 is a perspective view of a helical dielectric body providing an alternating current path constructed in accordance with this invention,

Fig. 2 is a front view in elevation with parts broken away of the helix shown in Fig. 1,

Fig. 3 is a perspective view of a helix of this invention associated with a high permeability core in suitable relation to act as a magnetic dipole antenna,

Fig. 4 is a perspective view of a helix of this invention with the end faces thereof located away from the eye of the helix to render it suitable for the creation of a more symmetrical magnetic field at the ends of the helix, and

Fig. 5 is a circuit diagram showing a bias circuit for adjusting the frequency range of a helix of this invention.

In the several forms of the apparatus of this invention herein described, a helix is prepared of a substance having a high dielectric constant such as the well-known titanates or stannates including, but not restricted to, the alkaline earth or alkali titanates or stannates or the barium or other titanates or stannates or the so-called complex titanates. It is sufficient only that a dielectric

2

substance be provided having a dielectric constant in excess of about 50 and preferably in excess of about 1000.

As a matter of first impression it might appear that such a dielectric helix or spiral is the effective equivalent of a capacitor and coil closely interconnected in a distributed shunt arrangement all combined into one unit. Careful mathematical analysis and actual measurements on the other hand confirm that the behavior is more complex, and is more closely related to properties of a lumped circuit element modified by the properties of an element having the characteristics of well-known electro-magnetic cavities. Since no cavity exists in the common sense, but on the contrary a volume quite densely filled, the term "inverse cavity" might be used with less likelihood of confusion.

In essence displacement currents of substantial magnitude, because of the high dielectric constant and peculiar boundary conditions become oriented in a fashion such that they, in effect, pursue the path of the helix. Mathematically, an inverse cavity, that is a body of dielectric of high dielectric constant and bare exterior surfaces functions in a manner akin to a cavity with conducting walls. Boundary conditions, however, are reversed and the action occurs in a much smaller volume. One consequence is that the inverse cavity exhibits as its lowest conceivable and realizable mode of oscillation, a quasi-degenerated TE mode that is not realizable in a cavity with conducting walls. This mode for a simple bare cylinder has only:

(a) An axial magnetic field, with a maximum at the center tapering off toward the outside to zero, according to a Bessel function of the first kind and zero order, and

(b) A radial electric field that is zero at the center, and is a function of the derivative of the above Bessel function.

If a radial sector is cut from such a cylinder and the two newly cut faces are furnished with separate electrodes in the form of separate metallized faces, an alternating current may be fed to these electrodes from a proper transmission line to produce field interchanges according to the above mode. In essence such a cut-away cylinder is a helix having something less than one full turn. In fact the cylinder may be cut away at the center to a considerable extent without notable change because it is here that the electric field is the least although the magnetic field is the strongest. If this single turn is given a pitch it may then be extended to a multiple turn helix of any desired number of turns.

In Figures 1 and 2 there are shown a dielectric helix of approximately five turns constructed in accordance with this invention. This helix comprises a body 1 composed of a substance having a high dielectric constant such as barium titanate or the like. The end faces of the helix turns are metallized to provide the end terminals 2 and 3. The central opening 4, within which the alternating magnetic field is most intense when terminals 2 and 3 are excited, may be occupied by such instrumentalities as one desires to influence.

Ordinarily the physical dimensions and the number of turns of the body 1 and its dielectric constants are proportioned to provide a helix coordinated as to input impedance with the characteristic impedance of the feeding transmission line.

One of the advantages of the helix of this invention is the ease with which optimum matching to specific frequencies can be obtained by simply applying an adjusted direct current bias potential to the end electrodes of the helix as shown in Fig. 5.

In the latter figure a helix 15 fed with alternating current from source 21 through leads 18, 19, 17 and 16 is joined in shunt relation to the adjustable voltage divider 20 which is supplied in turn by the direct current source

22. The reason such bias is effective is that the usual substances having high dielectric constants, are subject to substantial variation in their dielectric constants, in response to changes in applied D. C. bias. The coil 23 in lead 16 acts as a choke for the alternating current.

An instance of the utilization of the alternating magnetic field which may be established at the center of the helix of this invention is illustrated by the magnetic dipole antenna appearing in Fig. 3. Here a helix body 5, of substance having a high dielectric constant, is provided with metallized end faces forming electrodes 6 and 7. The end face electrodes are adapted to be joined or fed by transmission means in a circuit to or from which radiation is to be emitted or accepted. The central opening of the helix is occupied by a rod 8 of compacted iron powder, ferrite, or other suitable low reluctance substance. The helix body 5 is shown having but two turns. If an antenna having its response in other ranges is desired fewer or more turns may be employed as desired. As noted previously the properties of the helix of this invention are such that there is an inherent broad-band response. If such is not sufficient to cover the range desired the response may be extended as explained above by imposition of a biasing potential.

Where it is desired that the helix be employed to impose a concentrated rapidly alternating field upon a substance to be heated or upon an electron or other charged particle beam for focusing, modulating or otherwise, it may be desirable to place the end electrode faces away from the axis of the helix a distance greater than is the case in the helices described. For this purpose the helix of this invention may be constructed as appears in Fig. 4 where the body 8 of substance having a high dielectric constant is formed with ends 9 and 10, turned radially outwardly to provide faces away from the central opening 11, to which electrodes 12 and 13 are secured by metallizing.

The helices of this invention may be manufactured by heavily compacting fine granular titanate or other high dielectric material under heavy pressure in special molds of the shape desired, and then firing according to the well-known ceramic techniques employed for the preparation of such materials. Since the provision of such molds presents a difficult and expensive problem and may require the use of inserts which are intended to disintegrate on firing, a simplified procedure for making the helix may be useful.

Another method of constructing the helices of this invention which may be simpler, may be followed by first compacting a cylindrical body of granular titanate composition, or the like, having the approximate overall dimensions of the helix to be formed allowing for the usual shrinkage. This body is then prefired to form a bisque. In one instance a prefiring at 1100 degrees Fahrenheit for about four hours was found sufficient for this purpose.

The bisque cylinder was then machined with conventional machine tools into the shape of the helix desired, allowing, as before, for shrinkage. The machined helix may then be fired at temperatures and for intervals selected to develop the combination of electrical and other physical properties which may be desired. The end faces of the helix may then be metallized by silver-firing to provide the necessary intimate adherence of the electrodes.

Substances having high dielectric constants and low dissipation factors are well-known and such substances are to be chosen in preference to the dielectrics in which the Q or loss properties are poor. In constructing an antenna such as is shown in Fig. 3, it is advisable to offset the temperature coefficient of change of dielectric constant of the body 5, by choosing a magnetic material for the core 8, which has a permeability temperature coefficient of approximately the same magnitude but of opposite sign.

I claim:

1. In a dielectric coil a helix comprising one or more turns of dielectric substance having a dielectric constant in excess of about 50, the side surfaces of said helix turns being bare, and electrodes at the ends of said helix comprising areas of substances having the properties of metallic conduction in intimate contact with said helix ends, said coil being excitable as a resonant cavity when supplied with alternating current at said electrodes.

2. A magnetic dipole antenna for electrical frequencies of the upper frequency ranges comprising an open eyed helix of dielectric substance having a dielectric constant in excess of about 50 the side surfaces of said helix being bare, electrodes at the ends of said helix for transmission line connection comprising areas of substances having the properties of metallic conduction in intimate contact with said helix ends, and a body of high permeability substance disposed in the eye of said helix.

3. In a dielectric coil in accordance with claim 2, wherein the helix body is provided with ends extending away from the helix axis, with the electrodes in intimate contact with said extended ends.

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