United States Patent [19]

Root

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[54] **SERPENTINE ANTENNA MOUNTED ON A ROTATABLE CAPACITIVE COUPLER**

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[52] **U.S. Cl.** **343/741,** 343/806, 343/882

[51] **Int. Cl.** **H01q 9/16**

[58] **Field of Search**......343/741, 744, 748, 802, 806, 343/866, 908, 882

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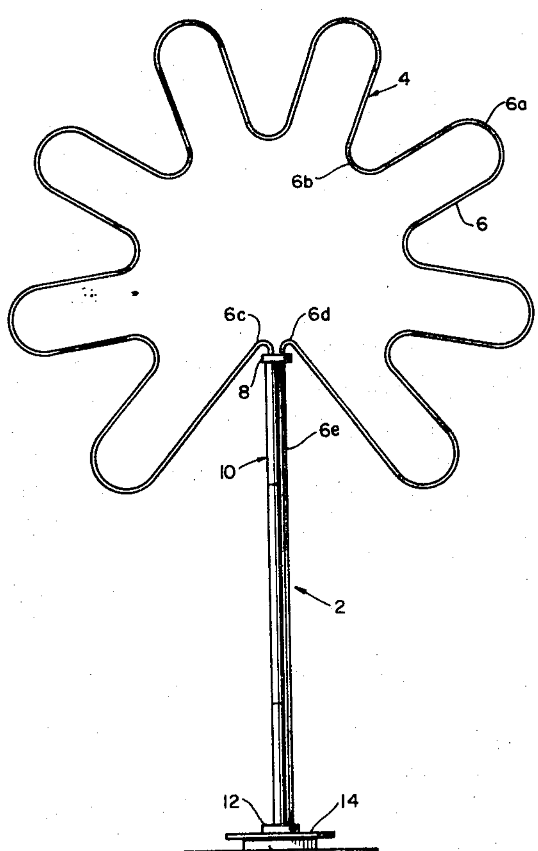
[57] **ABSTRACT**

This disclosure teaches an antenna including a conductor disposed in a serpentine arrangement defined by a plurality of undulations, wherein the amplitude or size of the undulations determines the directivity of the antenna, and wherein the undulations function to cancel mutual inductance parameters of the antenna while increasing the capacitive reactance thereof, to yield broadband characteristics. The antenna can take a variety of shapes, as for example the undulations may all fall entirely in a common plane and generally define a circle, a square, or an ellipse, etc.; or, such undulations may be arranged to form a ring or other three-dimensional object. The said shape of the antenna and its disposition with the earth's surface also contribute to the directivity of the antenna.

10 Claims, 8 Drawing Figures



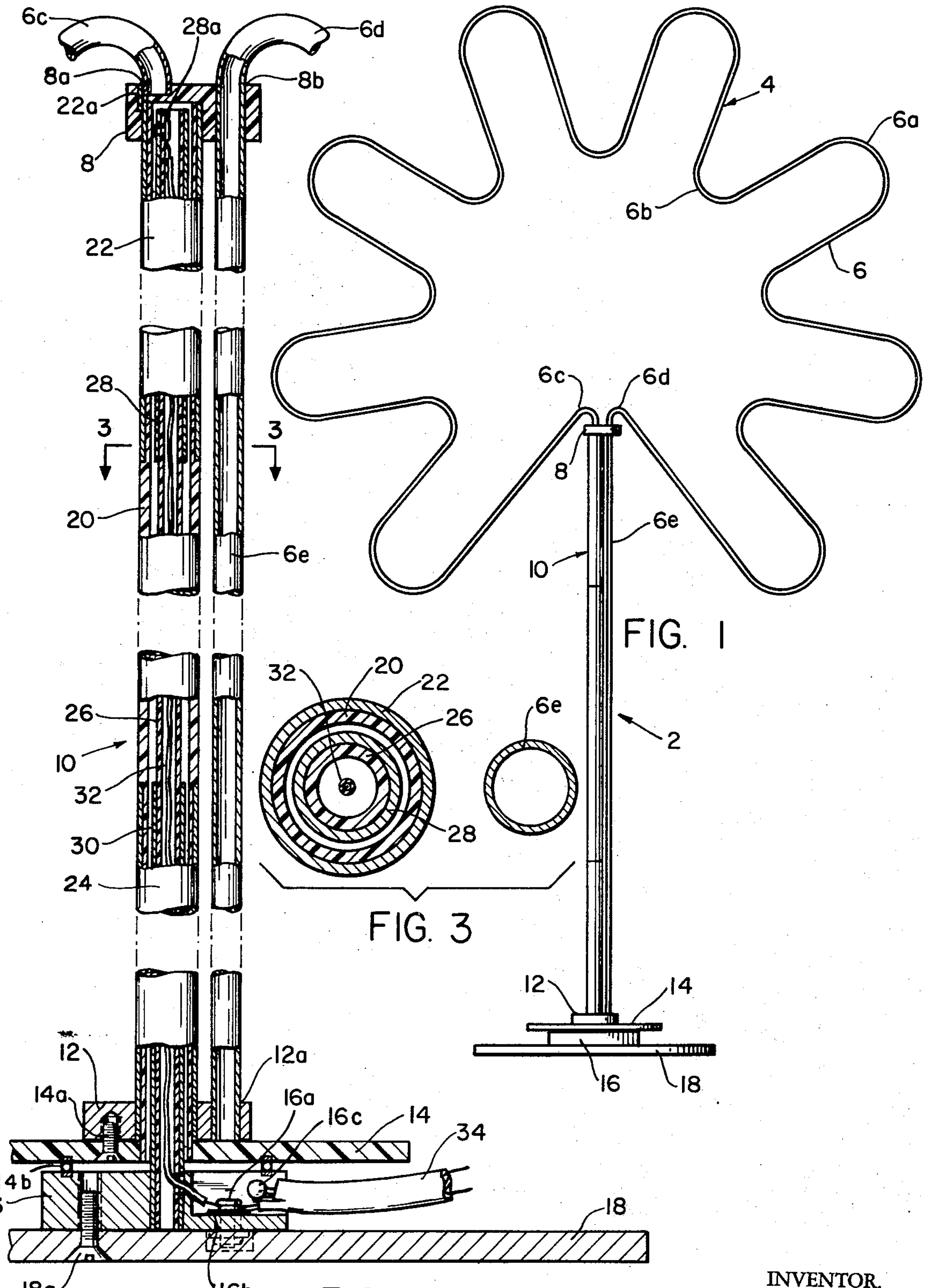


FIG. 2

FIG. 1

FIG. 3

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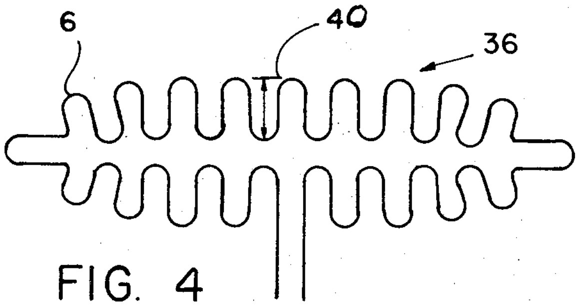

FIG. 4

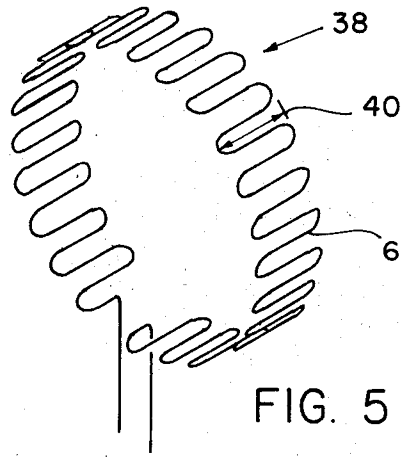

FIG. 5

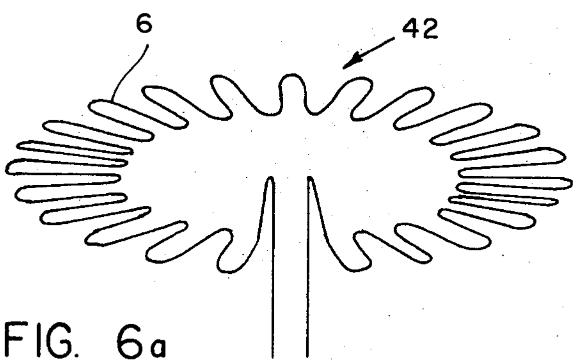

FIG. 6a

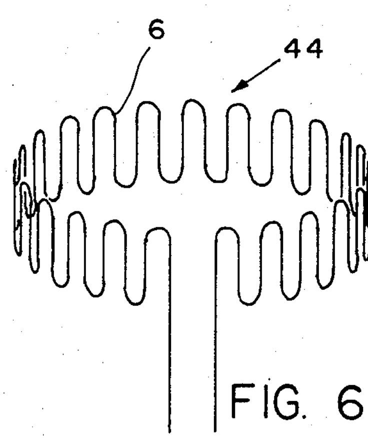

FIG. 6b

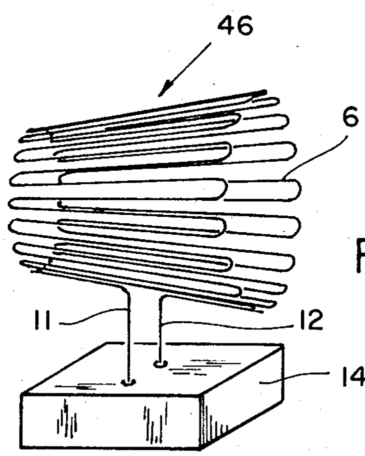

FIG. 7

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SERPENTINE ANTENNA MOUNTED ON A ROTATABLE CAPACITIVE COUPLER

BACKGROUND OF THE INVENTION

A conventional method of fabricating a broadband antenna is to couple together a plurality of highly-selective antennae. For example, a conventional television receiving antenna comprises a plurality of dipoles coupled together on a boom for connection to the television receiver. However, dipole antennae which are disposed adjacent each other are subject to an interaction which changes their individual characteristics in ways which are almost impossible to predict. Accordingly, it is usually necessary to experiment with antennae configurations in an effort to arrive at proper relationships between length and spacing of elements. A further problem of such conventional antennae is that they are highly directional and must be pointed towards the transmission source for good reception.

A principal object of this invention is to provide a broadband antenna which alleviates the coupling problems of conventional antennae, and which lends itself to a plurality of similar configurations providing widely varying directivity qualities.

SUMMARY OF THE INVENTION

In accordance with the invention, there is provided a broadband transmit/receive antenna including a conductor arranged in a serpentine configuration to provide a plurality of loop portions or undulations. The changing direction of the antenna element cancels mutual inductance between the undulations, and the capacitive reactance of the antenna is increased by increasing the number of undulations thereof. Thus, such an increase in the number of undulations causes an unbalanced reactance characteristic and a resultant increase in radiation resistance of the antenna system, thereby providing the antenna with a broadband frequency response.

The directivity of the antenna is controlled by the relative disposition of the individual undulations in the serpentine arrangement. For example, if the undulations are arranged in a common plane, then the directivity can be controlled by the positioning of the plane defined by the antenna. In this respect, the undulations can be arranged to form a circle, a diamond shape, a square or any other geometric configuration. Then, in another embodiment, the undulations can be formed in a band, or in the form of a truncated cone, to control the directivity of the antenna.

The directivity is also effected by the size or amplitude of each undulation in the serpentine arrangement. For example, if the undulations lie in a common plane, and if such amplitude defines one wavelength at the lowest desired frequency of the broadband antenna, then the directivity of the antenna is normal to the common plane in which the undulations lie. Alternatively, if the amplitude is arranged at one-half wavelength of the lowest frequency, then the directivity of the antenna is to the edges of the plane in which the element lies.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawing illustrates various modifications of a preferred embodiment of the invention. In such drawing:

FIG. **1** is an elevational view of a broadband antenna according to the invention;

FIG. **2** is an enlarged view of a support portion of the antenna of FIG. **1**, with sections broken away for clarity;

FIG. **3** is a sectional view taken along the line **3—3** of FIG. 2; and

FIGS. **4–7** are views similar to FIG. **1**, but showing antennae having different profiles than that illustrated in FIG. **1**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

As illustrated in the drawings, all of the modifications of the invention include an antenna element defining a serpentine arrangement of individual undulations. The undulations in each modification have the same size, and as described below, the relative disposition and size of the undulations determines the directivity of the antenna, while the number of undulations determines its broadband response.

In a rotational antenna assembly **2** according to the invention, as illustrated in FIGS. **1–3**, an antenna element portion **4** is formed by a continuous serpentine arrangement of antenna tubing **6**, and is mounted on a pedestal assembly **10**. The serpentine arrangement of the tubing **6** is formed by outer and inner bends **6*a*** and **6*b*** which define peaks and valleys of the loop portions or undulations, and which follow a generally circular path. A sleeve hollow member composed of portions **20, 22, 24** is held in an upright position with a straight portion **6*e*** of the tubing by spaced upper and lower discs **8** and **12**. One end **6*c*** of the tubing is mounted on the upper end of the sleeve portion adjacent a bent portion **6*d*** of the tubing and the portion **6*d*** defines the transition between the straight portion **6*e*** and the serpentine portion of the tubing **6**. The lower disc **12** is fixed to a rotatable support plate **14**, which in turn, rotatably rests by means of a conventional ball bearing **14*b*** on an electrical connector block **16** fixed to a base member **18**.

As shown, the element **4** and sleeve portions **20, 22** and **24** are fixed together and to plate **14** for rotation with respect to the base member and connector block **18** and **16**, which in turn are fixed together as by a screw **18*a***. That is, the end **6c** of the tubing **6** passes into a recess **8*a*** in the disc **8**, wherein it is electrically connected by a member **22*a*** to the upper end of conductive sleeve portion **22**. The conductive sleeve portion **22** is received over an upper section of the sleeve portion **20**, while the conductive sleeve portion **24** is received over a lower section of sleeve **20**, said sleeve **20** comprising an insulative tube fixed at its lower end to the insulative rotational plate **14**. On the other hand, the straight portion **6*e*** of the tubing passes through an opening **8*b*** in the insulative disc **8**, and is fixed at its lowermost end within an opening **12a** in the lower disc **12**, which in turn is fixed to the plate **14** as by a screw **14a**. Thus, the tubing end **6c** and the straight portion **6e** of the tubing are both fixedly interconnected with the plate **14** for rotation therewith.

A length of twin-lead cable **34** is provided and has one conductor connected directly to the metal conductor block **16** as at **16*c***, and its other conductor mounted insulatively on the block **16** as at **16*a*** and **16*b***. An insulative tube **26** extends upwardly from the base member

18 and has conductive sleeves 28 and 30 coaxially disposed thereon at its upper and lower portions, respectively. The lower sleeve 30 is fixed to the connector block 16, thereby providing an electrical connection between one of the twin lead conductors and the sleeve 30 and the sleeve 30 extend 5 upwardly and coaxially with the conductive sleeve 24. Thus, the straight tubing portion 6e is electrically coupled, directly, to the disc 12, which in turn is electrically coupled, directly, to the sleeve portion 24, which in turn is electrically coupled, indirectly, to the conductive sleeve 30 by the coaxial disposition therebetween.

An insulated conductor lead 32 is connected to the insulated mounting point 16a, 16b between the block 16 and the other conductor of the twin-lead cable 34, and the lead 32 passes upward through the insulative tube 26 for electrical connection to the upper conductive tube 28 as at 28a. Thus, the tube 28 and sleeve portion 22 provide an indirect electrical coupling along their coaxial extent to complete the antenna circuit.

Accordingly, the antenna assembly 2 provides a rotational antenna element 4 to facilitate adjustments in the directivity of the antenna.

The serpentine configuration functions to cancel the mutual inductance of the element 4 with the result that the capacitive reactance of the element has an increasing relationship with respect to an increase in the number of undulations. That is, a reactance imbalance occurs due to the decrease in inductance.

In the antenna illustrated in FIG. 1, all of the undulations of the tubing 6 are disposed in a common vertical plane, and are arranged in a circle, with the connecting leads of cable 34 being for coupling the antenna to a transmitting and/or receiving device. Both the antenna element of FIG. 1 and that of FIG. 4 provide for horizontal polarization of the antenna pattern, and as illustrated, the device of FIG. 4 differs from FIG. 1 only in the arrangement of undulations. That is, in FIG. 4, the antenna element forms an elongated oval shape 36 which provides the same broadband qualities and general directivity of the device of FIG. 1.

The various embodiments disclosed herein have been tested and have been found to provide, for example, a frequency response from 50 MHz to 890 MHz, whereby 50 MHz becomes the lowest frequency to be operatively applied to the antenna. Also, conventional coupling to the transmitter or receiver device is possible, as by stacking coupling or, as described above, by transmission lines to rotary devices.

In the antenna of FIG. 5, the undulations are arranged to form a band 38, wherein such undulations are defined axially of the band and advance circumferentially thereof. Again, in the modification of FIG. 5, the antenna pattern is polarized horizontally and has characteristics which are much the same as the antennae of FIGS. 1 and 4. In these three embodiments it has been found that the size or amplitude of each undulation, as indicated at reference numeral 40 in FIGS. 4 and 5 which designates the distance between peak and valley portions of the undulations in each of those views, has an effect on the directivity of the device, according to the following relationship: if the amplitude 40 is equal to one wavelength of the lowest frequency to be transmitted or received, then the antenna will have a pattern extending in opposing directions normal to a vertical plane through each undulation; and, if the undulation amplitudes define one-half wavelength of the lowest frequency, the directivity of the device changes so that it projects from the edges of the antenna.

FIGS. 6a and 6b show modifications of the antennae of FIGS. 1 and 5, respectively, wherein such antennae are identical except for the disposition of their principal planes; and, as shown, FIGS. 6a and 6b illustrate antennae, formed as bands 42 and 44 respectively, which are disposed horizontally as compared to the vertically disposed antennae of FIGS. 1 and 5.

Another modification as illustrated in FIG. 7, defines an antenna element which takes the shape of a truncated cone 46, wherein the undulations of the serpentine arrangement are disposed along the side walls of the cone. The directivity of the antenna of FIG. 7 is along the axis of the cone, and in the direction of the vertex thereof. Again, the broadband qualities of the device increase with an increase in the number of undulations.

I claim:

1. A broadband transmit/receive antenna comprising:

an antenna element having two ends and having between said two ends a continuous serpentine configuration defined by a plurality of serially connected together loop portions each orientated relative to its immediate adjacent loop portions to effectively cancel out mutual inductance occurring therebetween during use of the antenna;

support means for rotatably supporting said antenna element;

a pair of terminals connected to said support means and connectable to devices for transmitting and receiving electromagnetic energy during use of the antenna;

and means at least partially disposed interiorly of said support means for capacitively connecting each end of said antenna element to respective ones of said terminals.

2. A broadband transmit/receive antenna as set forth in claim 1, in which said plurality of loop portions comprise means defining a direct relationship between the capacitive reactance of said antenna element and the number of said loop portions.

3. A broadband transmit/receive antenna as set forth in claim 1, in which all said loop portions lie in a common plane.

4. A broadband transmit/receive antenna as set forth in claim 3, in which said plurality of loop portions comprise means defining an antenna directivity extending normal to said common plane when said loop portions are of equal size and are equal to one wavelength of the lowest frequency to be applied to said antenna, and said directivity is in said common plane when said loop-portions are of equal size and are equal to one-half wavelength of said lowest frequency.

5. A broadband transmit/receive antenna as set forth in claim 1, in which each said loop portion has a peak portion and a valley portion, and wherein each said peak portion lies in a first plane and each said valley portion lies in a second plane extending parallel to said first plane.

6. A broadband transmit/receive antenna as set forth in claim 5, in which said plurality of loop portions comprise means defining an antenna directivity extending normal to said first and second planes when said loop portions are of equal size and are equal to one wavelength of the lowest frequency to be applied to said antenna, and said directivity is in a plane parallel to said first and second planes when said loop portions are of equal size and equal to one-half wavelength of said lowest frequency.

7. A broadband transmit/receive antenna as set forth in claim 5, in which said plurality of loop portions form a hollow truncated cone having major and minor diameters, wherein said first plane is disposed at the minor diameter of said truncated cone and said second plane is disposed at the major diameter of said truncated cone, and wherein said plurality of loop portions comprise means defining an antenna directivity which is in a direction projecting outward from said first plane.

8. A broadband transmit/receive antenna as set forth in Claim 1, wherein said support means comprises a base member, an insulative sleeve, first and second conductive sleeve portions fixed on said insulative sleeve in axially spaced-apart relationship, means rotationally interconnecting said insulative sleeve with said base member, conductive means for electrically interconnecting one end of said antenna element to said first conductive sleeve portion and the other end of said element to said second conductive sleeve portion, first and second conductive terminals fixedly interconnected with said base member, an insulative tubular member fixed to said base member and disposed coaxially within said insulative sleeve, first and second conductive tubular members mounted in axially spaced-apart relationship on said insulative tubular member and extending coaxially and in opposed facing relationship with said first and second sleeve portions, respectively, and means connecting said first and second conductive terminals to said first and second tubular members, respectively.

9. A broadband transmit/receive antenna as set forth in Claim 1; wherein said support means comprises

a base member having connected thereto said pair of terminals,

an electrically insulated tube connected to and extending outwardly from said base member and having around the exterior thereof a pair of peripherally extending and axially spaced-apart electrically conductive portions,

a support plate having means therein defining an opening through which said tube extends,

means mounting said support plate for rotational movement around said tube,

a hollow member coaxially disposed around and spaced from said tube and connected to said support plate to undergo rotational movement therewith around said tube and having a pair of electrically conductive portions peripherally extending thereover and axially spaced-apart therealong each in opposing spaced-apart relationship from respective ones of said electrically conductive portions of said tube,

and means electrically connecting said two ends of said antenna element to respective ones of said electrically conductive portions of said hollow member and electrically connecting said pair of terminals to respective ones of said electrically conductive portions of said tube,

whereby said antenna element may be angularly displaced to vary the antenna directivity.

10. A broadband transmit/receive antenna as set forth in claim 9;

wherein said electrically conductive portions of said tube and hollow member comprise annular sleeves connected to said tube and hollow member.

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