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[54] ANTENNA SYSTEM WITH FERRITE RADIATION SUPPRESSORS MOUNTED ON FEED LINE

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[52] **U.S. Cl.** **343/792,** 343/885, 333/12

[51] **Int. Cl.** **H01q 1/50**

[58] **Field of Search** 343/787, 790, 791, 792, 885; 333/25, 12

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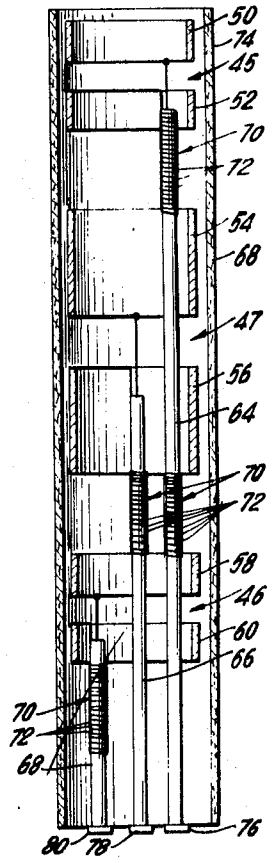
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[57] **ABSTRACT**

A high frequency antenna system comprises an antenna, a transmission line such as a coaxial cable electrically connected to the antenna, and a magnetic member surrounding the outer conductor of the coaxial cable. The magnetic member suppresses extraneous currents that are induced in the outer conductor of the coaxial cable by radiations from the antenna. By suppressing the extraneous current in the outer conductor distortion of radiations is prevented. In the preferred embodiment, the magnetic member comprises a plurality of ferrite toroids which collectively form a cylindrical covering on the conductor. Several antenna systems of this type may be closely spaced in a compact array, and each system may operate independently of the others in the array without interference between antennas.

2 Claims, 6 Drawing Figures



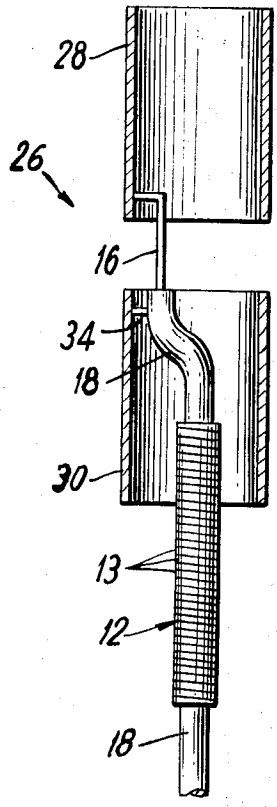


FIG.1

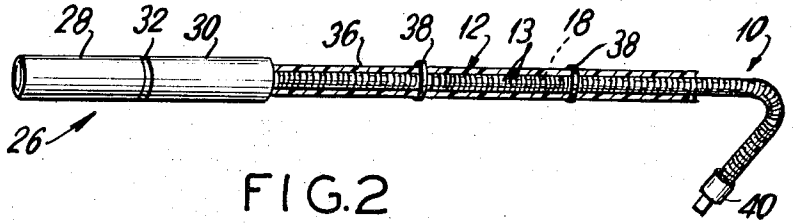


FIG.2

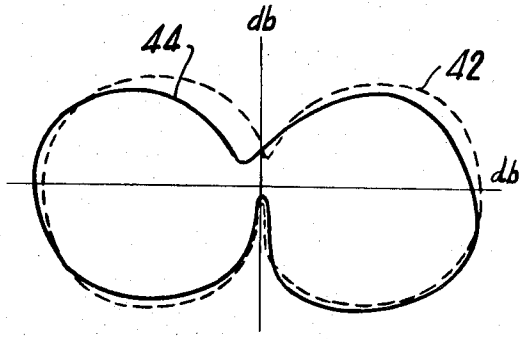


FIG.3

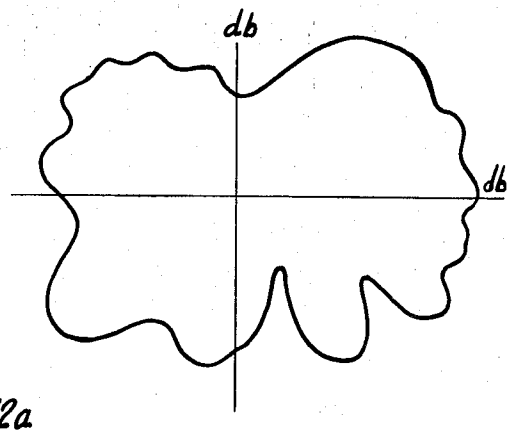


FIG.4

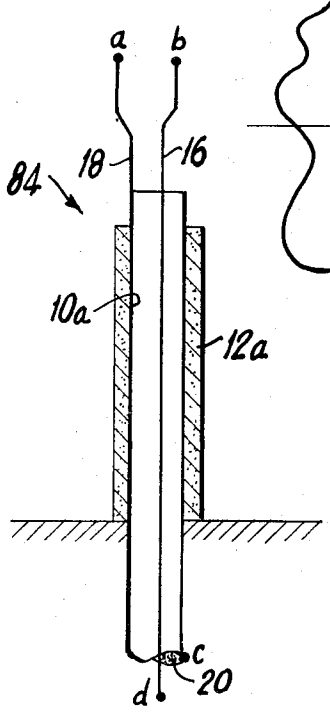


FIG.6

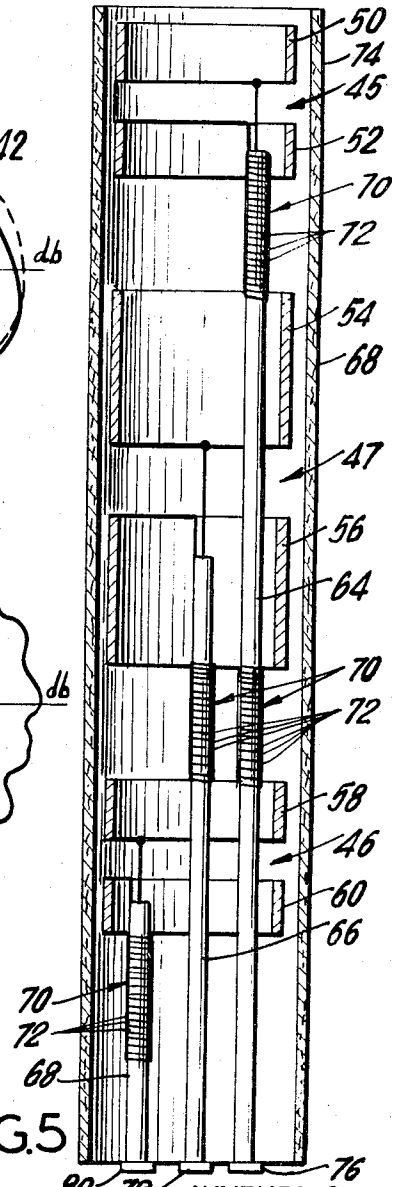


FIG.5

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ANTENNA SYSTEM WITH FERRITE RADIATION SUPPRESSORS MOUNTED ON FEED LINE

This invention relates to high frequency antennas, and more specifically to means for reducing or eliminating the distortion of radiations usually associated with a long transmission feed line.

In high frequency transmission systems the transmitting antenna may often be located at a considerable distance from the transmitter or current feed source. A long transmission line is therefore required. A coaxial cable is the most common form of transmission line used for this purpose as it is structured to feed the current to the antenna with a minimum of signal loss and with no appreciable electromagnetic radiation from the line itself. Distortion of radiations, however, is normally encounted with long transmission lines because stray radiations induce extraneous currents in the line, usually in the outer conductor. The extraneous and spurious currents are fed to the antenna along with the primary energy thereby causing the distortions.

Extraneous currents may be caused by any of several current inducing forces acting on the line. For example, stray radiations from other nearby transmission systems are frequently the cause. Further, the conductivity level of the ground in the vicinity of the coaxial cable is an influencing factor as the outer conductor is grounded.

It is also known that the degree of wave distortion is directly related to the effective length of the antenna and the length of transmission line. For example, the electric field component of a wave radiated from a half-wavelength antenna ideally is a "figure 8" pattern, which becomes distorted to a "clover-leaf" pattern as the effective antenna length increases from one-half to three half-wavelengths. Further increases in antenna length are accompanied by further distortions in the electric field component.

It is most desirable, therefore, to reduce the transmission line length as much as possible. Oftentimes, however, this is impractical to control and other means of eliminating wave distortion must be used. One common remedy is that known as a "ground plane" which is a system of copper wires buried in the ground in the vicinity of the antenna. This system of buried wires is effective to alter the conductivity level of the ground and thus stabilize the current flow in the grounded outer conductor of the coaxial cable transmission line. While such system is somewhat successful in reducing wave distortion, it is impractical to employ because of the large physical arrangement of the ground plane and the substantial time required to set up the system.

Another technique comprises placing a plurality of high frequency chokes in contact with the outer conductor of the coaxial cable. These chokes are in the form of sections of coaxial cable having a length to present a high impedance to current flow in the outer conductor. Because a plurality of such chokes must be welded or mechanically attached along the cable, the assembly is physically large and cumbersome. Furthermore, because of the nature of this type of choke, it is effective over only a small operating frequency range.

The problem of wave distortion is particularly important where multi-antenna arrays are involved. It is important in array applications that each antenna be isolated from the others.

There has been, therefore, a strong demand for light-weight, compact and efficient means to limit or prevent distortions in the radiation patterns resulting from the effect of stray radiations on the transmission line. Isolation is particularly difficult where several coaxial cables, feeding the antennas in the array, are in close proximity to each other and to the antennas. Stray radiations are substantial and have a significant effect on the radiation patterns from the individual antennas. Further, communication frequencies are now in the megacycle range requiring physically small antennas, so that isolation devices must also be small.

Recent efforts to solve this problem have been unavailing. For example, in one assembly, three dipole radiators of a desired size were coaxially aligned and spaced from each other by an outer insulating supporting cover. When a high frequency current was transmitted to each dipole through a long transmission line, independent operation of the radiators could not be maintained because of poor isolation and the resulting high level of interference. Lossy material was placed around the transmission lines between the radiators, but the performance of the radiators was not improved. An attempt has been made to arrange the several radiators concentrically instead of in axial relationships but the concentric arrangement was not successful.

Accordingly, it is the primary object of the invention to provide means for suppressing extraneous currents in the transmission line of a high frequency transmission system.

It is another object of the invention to provide a compact and lightweight mechanical assembly in which several independently operating transmitting antennas are strongly electrically isolated from each other over a wide frequency range.

Broadly, the above objects are satisfied and the aforementioned difficulties are overcome by the use of a magnetic member which at least partially surrounds the antenna transmission line. It has been discovered that such a member suppresses, or eliminates the extraneous currents in the transmission line, and thus radiations from the antenna connected to the line are substantially undistorted.

In the preferred embodiment of the invention, the magnetic member is composed of a ferrite material. The ferrite is formed into a toroid and a plurality of these toroids are placed over the outer conductor of the coaxial cable to form collectively a cylindrical outer covering on the cable. The toroids are slipped over the end of the cable and moved to a suitable location on the cable until all or a desired part of the cable is surrounded. The use of toroids is desirable as cable flexibility is maintained.

The novel antenna system has particular utility in a multi-antenna array in which the several antennas are isolated from each other by the magnetic members and the antenna systems are capable of operating independently at different frequencies without mutual interference and over a wide frequency range. In one embodiment, a plurality of antennas are closely spaced and coaxially aligned by a supporting sleeve of an insulating material. Coaxial cable transmission lines are connected to each antenna in the conventional manner. The ferrite member surrounds each cable in the space between the adjacent antennas. In this way, isolation is achieved in a compact assembly. In one embodiment, the antennas and insulating sleeve were hollow tubular devices and were connected to form a long cylindrical structure. The coaxial cables passed through the interior of this structure to their respective connection points on the antennas. The structure was relatively light, compact and operable over a wide frequency range, free of mutual interference.

The combination of a transmission line and a magnetic member surrounding the line is also useful for other applications in a transmission system. For example, the combination may be employed as a balun. As is known, a balun converts a balanced line into an unbalanced line and vice versa. The operation of a balun involves the transfer of energy e.g. from an unbalanced condition such as the distribution of currents inside a coaxial transmission line, to a balanced condition such as is typical of the distribution of current on an open two-wire transmission line. Presently available baluns employ a short circuited quarter-wavelength open transmission line at certain terminals to present a high impedance at those terminals for balancing the transmission lines. A ferrite member surrounding a coaxial cable provides a similar high impedance and therefore may serve as a balun. With this structure, the frequency sensitive quarter wavelength line is eliminated thereby providing a simple and better stabilized device.

To the accomplishment of the foregoing, and to such other objects as may hereinafter appear, the present invention relates to an antenna system as defined in the appended claims and as described in the accompanying drawings in which:

FIG. 1 is a schematic illustration of a combination of a coaxial transmission line and an antenna according to the present invention;

FIG. 2 is a perspective view of the components schematically illustrated in FIG. 1;

FIG. 3 is an approximate graphical illustration of the electrical field component of an electromagnetic wave radiated by the antenna of FIG. 1;

FIG. 4 is an approximate graphical illustration of the electrical field component of an electromagnetic wave generated by the antenna of FIG. 1 without the use of a magnetic member;

FIG. 5 is a cross-sectional view of a multi-antenna array, and

FIG. 6 is a schematic illustration of a balun utilizing the feature of the invention.

Referring to FIGS. 1 and 2, there is shown a coaxial transmission line **10** surrounded by a magnetic member **12**. The member **12** preferably is a ferrite sleeve or cylinder or it may be in the form of a plurality of ferrite toroids which collectively form a ferrite cylinder. The transmission line **10** comprises an inner conductor **16** and an outer conductor **18**, which are separated by an insulating material **20**. The ferrite cylinder **12** has an inside diameter slightly larger than the outer diameter of the coaxial transmission line to ensure a reliably snug fit of the ferrite cylinder **12** the transmission line. An antenna **26** is connected to the coaxial transmission line **10** to receive high frequency signals from the line.

Antenna **26** is here shown as a dipole antenna having two equally dimensioned sections **28** and **30** which, as shown in FIG. **2**, may be maintained in a spaced relation by a suitable insulative dielectric spacer **32**. The inner conductor **16** of the coaxial transmission line is electrically connected to section **28**, while the outer conductor **18** of the transmission line is electrically connected to section **30** by a wire **34**. Antenna sections **28** and **30** are thereby polarized to conform to the respective potentials on conductors **16** and **18**, and radiate high frequency electromagnetic energy in response to current fed to the antenna by the transmission line. As shown in FIG. **2**, coaxial transmission line **10** is secured to an outer sleeve **36** by a suitable holding means **38** and is provided with a connection **40** at one end which is adapted to be connected to a current feeding source (not shown).

The radiation pattern of an ideal dipole antenna is illustrated in the broken-line pattern **42** in FIG. **3**, as being generally symmetrical about the zenith and having a minimum radiation along the zenith. Due to the long length of coaxial line **10**, the effective length of antenna **26** is increased. Without the provision of the magnetic member **12** about the outer conductor of line **10**, extraneous currents would be induced in the outer conductor of the coaxial line which causes a distortion of the radiation pattern, and the antenna assembly of FIGS. **1** and **2** would in that case produce a radiation pattern as illustrated in FIG. **4**.

In the antenna assembly of the invention in which the magnetic member **12** surrounds the outer conductor of the coaxial line **10**, these extraneous currents are substantially suppressed or practically eliminated. The resultant radiation pattern of the antenna assembly of the invention becomes the pattern **44** shown in the solid line pattern of FIG. **3**. The vast improvement in the radiation pattern provided by the antenna assembly of the invention due to the provision of the magnetic member is readily observed by a comparison of the ideal dipole pattern **42** in FIG. **3**, the realized pattern **44** in FIG. **3**, and the radiation pattern obtained for the conventional antenna of FIG. **4**.

FIG. **5** illustrates a multi-antenna array comprising a plurality of antennas. The array comprises UHF antennas **45** and **46**, and a VHF antenna **47** interposed between the two UHF antennas. The three antennas are arranged substantially coaxially and are spaced from one another. Each of the antennas comprises two axially spaced cylindrical metal sections which are comparable in construction and operation to sections **28** and **30** of the antenna assembly of FIG. **1** and **2**. Thus antenna **45** comprises sections **50** and **52**, antenna **47** comprises sections **54** and **56**, and antenna **46** comprises sections **58** and **60**. Antennas **45**, **46** and **47** respectively receive energizing current from coaxial transmission lines **64**, **66** and **68** which are connected to their associated antennas in the manner described above with reference to FIG. **1**.

Magnetic members **70** comprising a plurality of ferrite toroids **72** are assembled about each of coaxial lines **64–68** in the spaces between the antennas to achieve satisfactory isolation between the antennas. The ferrite toroids are arranged axially along the coaxial lines and collectively define a cylindrical magnetic sleeve or cylinder about those portions of the lines located in the spaces between the antenna radiators. The multi-array antenna may be enclosed in a suitable fiberglass support radome **74**, and coaxial connectors **76,78** and **80** are respectively connected to the input ends of coaxial transmission lines **64**, **66** and **68**.

Each of these antenna systems may operate at different frequency ranges without adverse affects on the other system. Tests performed on the multi-array antenna system of FIG. **5** indicate that the radiation patterns of each of the three antennas closely approximates that of a simple dipole in free space as illustrated in FIG. **3**. The insertion of the ferrite material about the outer shield of the coaxial transmission lines **64–68** thus effectively eliminates the undesired extraneous currents that are induced in the lines. This effect is probably the result of the increased inductive reactance of the conductor including the outer shield of the coaxial line due to the provision of the ferrite material in the UHF and VHF ranges. Moreover, at frequencies between 115 and 440 MHZ, significant isolation between the antenna sections ranging from 30db between antennas **45** and **47**, to as high as 55db between UHF antennas **45** and **46**, was obtained.

Another use of the coaxial cable and surrounding magnetic member is as a balun generally designated **84** as illustrated in FIG. **6**. The balun comprises the ferrite cylinder **12***a* encased about the outer conductor of a coaxial transmission line **10***a*. The balun **84** includes balanced terminals *a* and *b* and unbalanced terminals *c* and *d*. These latter terminals would actually be at some distance from ferrite cylinder **12***a* but are shown adjacent the cylinder for illustrative purposes. The several terminals are connected to the conductors **16** and **18** of the coaxial cable **14** as shown. In the typical operation of this balun a conversion from the unbalanced terminals *c*, *d* to the balanced terminals *a*, *b* is effected as a result of the high impedance presented at terminals *a*, *b* by the ferrite cylinder **12***a*. The unbalanced condition at remote terminals *c*, *d* is that typically found in the coaxial cable between inner conductor **16** and the outer grounded conductor **18**. However, the high impedance looking back at terminals *a*, *b* is caused by the attachment of the high impedance ferrite cylinder **12***a* to conductor **18** and this inhibits current flow to the normally grounded outer conductor **18**. As a result, each conductor **16** and **18** is effectively isolated above ground at terminals *a* and *b*, thereby causing a balancing of these terminals relative to ground, which produces a balanced condition on the two-wire line.

While the several embodiments shown illustrate the ferrite member as a cylindrical tube formed by a plurality of ferrite toroids arranged axially about a coaxial transmission line, it will be appreciated that the ferrite member may be constructed in any suitable shape provided that it surrounds at least a part of the outer conductor of the coaxial transmission line. The ferrite itself may be any one of the commercially available grades of this material such as TYPE Q–1 or H manufacturer by the Indiana General Corporation. It is readily manufactured in a toroid or cylindrical shape for use in the systems herein described.

From the foregoing it will be appreciated that by surrounding a transmission line such as a coaxial cable with a magnetic member in an antenna system, a simple solution is provided to a long standing problem. Excellent radiation pattern generation is assured at high frequencies both for a single antenna

and for a plurality of closely positioned independently operating antennas. A lightweight, compact multi-antenna assembly may now be readily provided without wave distortion caused by the extraneous currents induced in the outer conductors of the coaxial line in the prior art feed systems, and without the bulky equipment heretofore required. In addition, the magnetic member and coaxial transmission line may be employed in other important applications in a transmission system such as a balun.

While several embodiments have been described, it will be apparent that many other modifications of the invention may be made without departing from the spirit and scope of the invention.

I claim:

1. A high frequency antenna assembly comprising at least first and second coaxially arranged cylindrical antenna elements for independently transmitting electromagnetic waves at respectively different first and second frequencies, means for supporting said first and second antenna elements at axially and relatively closely spaced positions relative to one another, first and second coaxial transmission lines arranged coaxially with said first and second antenna elements and having a center conductor coupled respectively to said first and second antenna elements for respectively supplying energizing current to said first and second antenna elements, at least one of said first and second transmission lines passing through one of said first and second antenna elements to which it is not coupled, and first and second magnetic members each including a plurality of coaxially arranged ferrite toroids surrounding the outer shield of said one of said first and second transmission lines in the space between said first and second elements.

2. The assembly of claim 1, in which at least a first one of said antenna means is adapted to transmit electromagnetic waves in the UHF range and at least a second one of said antenna means is adapted to transmit electromagnetic waves in the VHF range.

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