DUAL LINEAR/CIRCULAR POLARIZATION SPIRAL ANTENNA

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FIG. 1

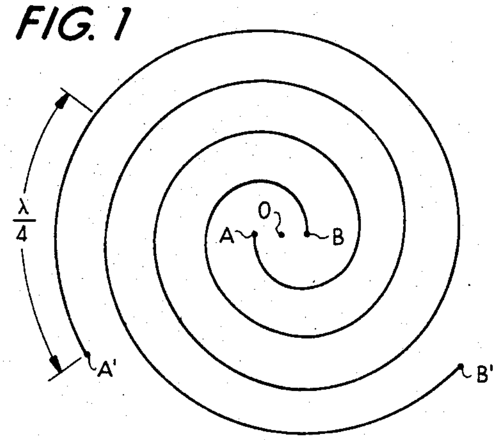


FIG. 2

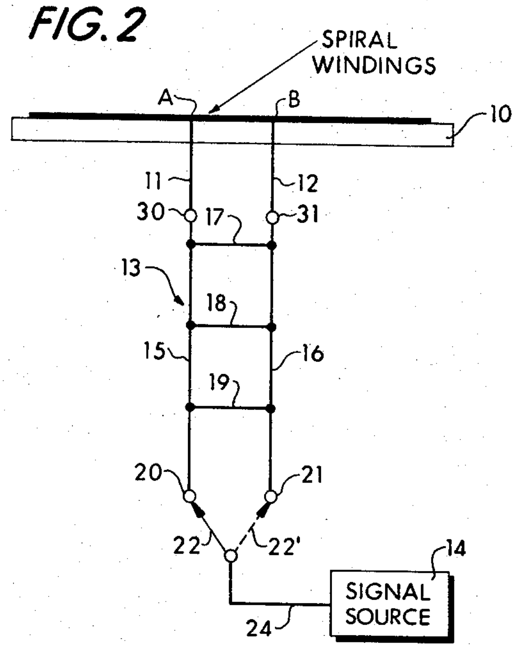
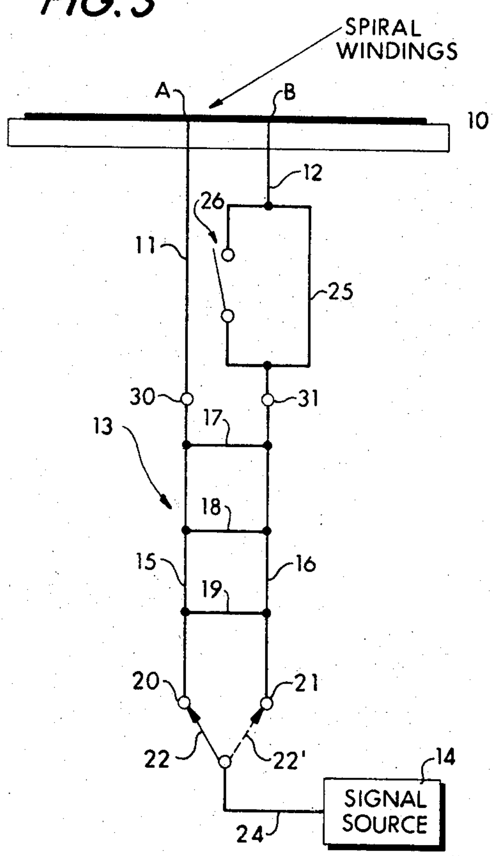


FIG. 3



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DUAL LINEAR/CIRCULAR POLARIZATION SPIRAL ANTENNA

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ABSTRACT OF THE DISCLOSURE

A spiral antenna system capable of selectively providing linearly or circularly polarized radiation. The antenna has a pair of spiral arms, differing in length by one quarter wavelength, which are energized by a pair of quadrature-phased signals from a quadrature feed device to provide linear polarization. A 90° plane shifter can be selectively interconnected between the feed device and the shorter of the two spiral arms to provide circular polarization.

This invention relates generally to antenna systems, and more particularly to a spiral antenna system wherein dual linear/circular polarization is provided by a single spiral antenna.

The spiral antenna is well known in the art, and is widely used to transmit circularly polarized waves. In one well known version, the antenna comprises a pair of bifilar spirally wound conductors of equal length. When the inner ends of the conductors are energized with anti-phase signals, circularly polarized radiation results having the same sense as that of the spirally wound conductors. Radiation of opposite sense results when the outer ends of the conductor are energized. Another version of the spiral antenna employs a pair of bifilar spirally wound conductors with the spiral windings differing in length by one-quarter wavelength. This antenna produces circularly polarized radiation when energized with in-phase signals applied to the conductors.

It would be advantageous in many instances to be able to generate linearly polarized, as well as circularly polarized, radiation from the same antenna. One method for providing such polarization diversity employs a spiral antenna which is simultaneously energized at its inner and outer ends to thereby produce linearly polarized radiation. This antenna, however, requires extremely careful phasing and balancing of the input signals in order to produce linear polarization and, therefore, is a relatively complex and expensive means of accomplishing the desired result. Another known system employs two spiral antennas each wound with opposite sense, and simultaneously energized to produce a linearly polarized far field radiation pattern. Still another known system produces linear polarization by means of a spiral antenna operated in conjunction with a reflector and parasitic elements. These last-mentioned systems are rather complex and their practical applications limited by reason of their complexity, cost and size. In addition, these last-mentioned systems, while capable of producing linear polarization, are not readily adaptable to providing circular polarization. It is, therefore, a primary object of the present invention to provide a simple antenna system capable of producing both linear and circular polarization.

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Another object of the invention is to provide a spiral antenna capable of producing linear and circular polarization with only a single energizing source.

A further object of the invention is to provide an antenna system wherein the sense of linear polarization is easily varied.

Applicant has discovered that a spiral antenna can provide linear polarization when energized with a quadrature phased signal having both in-phase and out-of-phase components of equal amplitude. The in-phase signal components produce circular polarization of one sense, while the out-of-phase signal components produce circular polarization of opposite sense, the two senses of circular polarization combining to produce the desired linear polarization. Applicant has also discovered that by altering the relative polarity of the applied energizing signals, the sense of the linear polarization can be correspondingly varied by 90°. By the use of a simple switching device, the antenna can also produce either sense of circular polarization.

The invention will be more fully understood from the following detailed description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic representation of a spiral antenna of the type useful in the present invention;

FIG. 2 is a schematic representation of an antenna system according to the invention; and

FIG. 3 is a schematic representation of another embodiment of the invention.

Referring to FIG. 1, there is shown a spiral antenna having inner feed points A and B, equally spaced about the center O of the spiral configuration. The inner feed points A and B are respectively connected to two spiral windings AA′ and BB′, where the length of the spiral winding AA′ is a quarter of a wavelength longer than the spiral winding BB′. When balanced anti-phase (0°–180°) signals are applied to inner feed points A and B, respectively, no radiation occurs at the feed points because the signals are out of phase and there is no circulating current. As the signal currents in the respective spiral windings progress outward from the feed points, the currents gradually become in-phase in adjacent windings, until at a radius equal to $\tau(2\pi)^{-1}$ the currents are precisely in phase and maximum radiation occurs. This produces one sense of circular polarization as seen in the far field. Conversely, if balanced in-phase (0°—0°) signals are applied to feed points A and B, respectively, no radiation occurs at the feed points because of the lack of circulating currents. As the signals in the respective windings progress outward along the spiral, no radiation occurs during the outward progression since the currents in adjacent windings are never in-phase, and the signals reach the ends of the windings practically undiminshed in amplitude. The signals are reflected backward along the spiral windings and, because of the quarter wavelength difference in the length of the windings, the signal on winding AA′ travels a half wavelength further than the signal on winding BB′. Therefore, during the inward progression of the currents along the spiral windings, the current in the adjacent windings gradually become in-phase, until at a radius equal to $\tau(2\pi)^{-1}$, the currents are precisely in-phase and maximum radiation occurs. Because the radiation occurs during the inward progression of the signals on the spiral windings with 0°—0° feed, the sense of circular polarization produced in opposite to the sense produced with 0°–180° feed.

Applicant has now discovered that linear polarization can be produced by employing an energizing signal having both in-phase and anti-phase components, such as a quadrature phased signal. The in-phase components produce one sense of circular polarization, while the anti-phase components produce the opposite sense of circular polarization, and both senses of circular polarization then combine to produce the desired linear polarization.

An antenna system embodying the invention is illustrated in FIG. 2. The spiral windings are shown (in side view) mounted on a suitable backing material **10**, for example by etched circuit techniques, with input lines **11** and **12** connected to inner feed points A and B, respectively. A quadrature feed device, such as quadrature hybrid **13**, is connected between input terminals **20** and **21** and output terminals **30** and **31**, and includes a pair of transmission lines **15** and **16** interconnected at quater-wave intervals by lines **17**, **18** and **19**. The output terminals **30** and **31** of quadrature hybrid **13** are connected to respective feed lines **11** and **12**.

In operation, a signal from source **14** is applied via line **24** to a two position switch **22**(**22′**). In switch position **22**, the output of signal source **14** is applied to input terminal **20** of the quadrature hybrid; in switch position **22′**, the output of the signal source is applied to input terminal **21** of the quadrature hybrid.

When a signal from signal source **14** is applied to input terminal **20**, a pair of quadrature phased signals appear at hybrid terminals **30** and **31**, by action of quadrature hybrid **13**, and are applied, respectively, to antenna terminals A and B via lines **11** and **12**. A signal applied to input terminal **22′** also produces a pair of quadrature signals at terminals **30** and **31**; however, the sense of the signals is opposite to that produced via input terminal **22**, since the polarity of the quadrature signals is reversed.

Since in either of the above cases the signals applied to the inner feed points A and B are out-of-phase by 90°, it will be appreciated that such signals are devisable into two pairs of component signals, wherein one pair of component signals are in-phase (0°—0°) and one pair of component signals are anti-phase (0°–180°). As described previously, the components signals which are anti-phase (0°–180°) gradually become in-phase during the outward progression along the spiral windings and are precisely in-phase on adjacent windings at a radius equal to $\tau(2\pi)^{-1}$ where radiation having one sense of circular polarization occurs. The signal components which are initially in-phase (0°—0°) progress outward on the spiral windings and are reflected back at the ends of the windings and become in-phase again at a radius equal to $\tau(2\pi)^{-1}$, but, because they are traveling in the opposite direction, produce circular polarization of opposite sense to that produced by the anti-phase signal components. The two opposite senses of circular polarization combine in the far field to produce linear polarization. The attitude of the linear polarization can be easily varied by switch **22**. When the switch is connected to input terminal **20**, the liner polarization produced by the antenna is orthogonal to that produced when the switch is connected to input terminal **21** of quadrature hybrid **13**, due to the opposite polarity of the energizing signals.

Another embodiment of the invention is illustrated in FIG. 3 by which circular polarization can be provided, in adidtion to linear polarization, and includes a 90° phase shifting device **25**, for example a quarter-wave line, connected between output terminal **31** of quadrature hybrid **13**, and input line **12** of the spiral antenna, and having a switch **26** connected across the input and output terminals. The switch may be, for example, a simple diode switch. When switch **26** is open, phase shifter **25** is in the transmission path from terminal **31** to inner feed point B, while the phase shifter is shorted out of this transmission path when switch **26** is closed. Phase shifting device **25** is designed to be relatively frequency independent over the bandwidth of operation of the antenna system.

When switch **26** is closed, the operation of the system of FIG. 3 is the same as that of FIG. 2. When switch **26** is open, however, and a signal is applied to input terminal **20** of the quadrature hybrid, one portion of the signal is applied directly to inner feed point A of the spiral antenna element, while the other portion of the signal is delayed by 90° by action of quadrature hybrid **13**, and is delayed by an additional 90° by phase shifting device **25** before reaching inner feed point B. As a result, the signal at point B is 180° out-of-phase with the signal at point A, causing the antenna to radiate circular polarization. Conversely, when the signal is applied to input terminal **21** (switch position **22′**), the signal applied to point A is delayed by 90° by quadrature hybrid **13**, and the signal applied to point B is delayed by 90° by phase shifter **25**, so that the signals at points A and B are in-phase (0°—0°), causing circular polarization of opposite sense. Thus, utilizing the configuration of FIG. 3 with switch **26** open, it is possible to produce either sense of circular polarization, while with switch **26** in the closed position, linear polarization having one of two senses is produced.

From the foregoing, it is readily apparent that a spiral antenna system has been provided which can produce dual linear/circular polarization. Utilizing simple switching techniques, this system can produce either sense of circular polarization, as well as either of two orthogonal linear polarizations. The utility of the invention is enhanced by its relatively simple structure, since it requires only a single spiral antenna element, a single signal source, and relatively simple feeding devices for transmitting the signal from its source to the antenna element.

While particular embodiments of the present invention have been shown and described, many modifications and variations will become obvious to those skilled in the are without departing from the true spirit of the invention. For example, many different forms of feeding devices to produce the desired quadrature phase signals are available. In addition, switch **26** and phase shifting device **25** of FIG. 3 may take a variety of forms to meet particular design requirements. The invention, therefore, is to be limited only to the extent of the following claims.

What is claimed is:

1. An antenna system comprising, in combination, a spiral antenna having first and second spiral windings differing in length by approximately one quarter wavelength at the operating frequency and each having an inner feed point, a phase shifting device having an input terminal and an output terminal, means connecting the output terminal of said phase shifting device to the inner feed point of said second spiral winding, a quadrature feed device having first and second input terminals and first and second output terminals, means connecting the first output terminal of said quadrature feed device to the inner feed point of said first spiral winding, means connecting the second output terminal of said quadrature feed device to the input terminal of said phase shifting device, means for applying a direct connection between the input terminal and the output terminal of said phase shifting device, and means for selectively applying a signal to the first or the second input terminal of said quadrature feed device.

2. A spiral antenna for selectively providing linearly or circularly polarized radiation, comprising:

first and second bifilar spirally wound conductive windings differing in length by one quarter wavelength at the operating frequency and each having an inner feed point, said first winding being longer than said second winding;

a quadrature feed device having a first output coupled to the feed point of said first winding and a second output coupled to the feed point of said second winding;

a 90° phase shifter;

means for selectively connecting said phase shifter between the second output of said quadrature feed device and the feed point of said second winding; and

means for applying an energizing signal to an input terminal of said quadrature feed device.

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