June 12, 1962 H. N. CHAIT ET AL 3,039,099

LINEARLY POLARIZED SPIRAL ANTENNA SYSTEM

Filed June 25, 1959

FIG-1

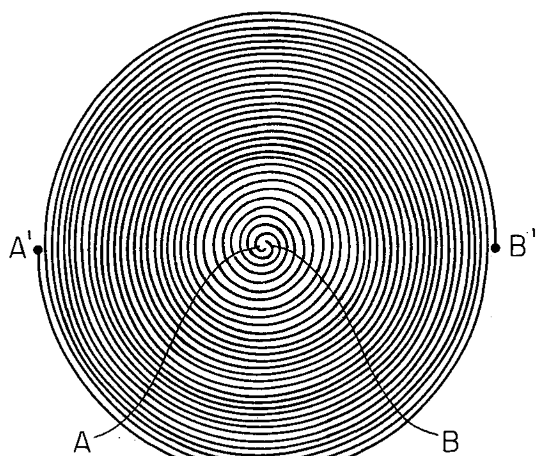


FIG-3

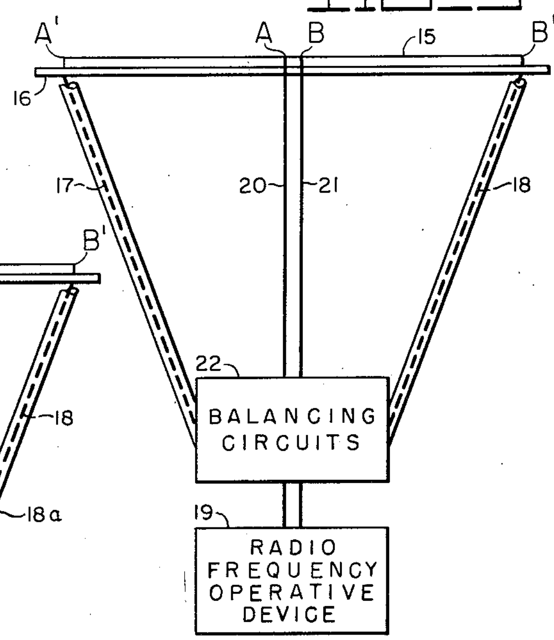
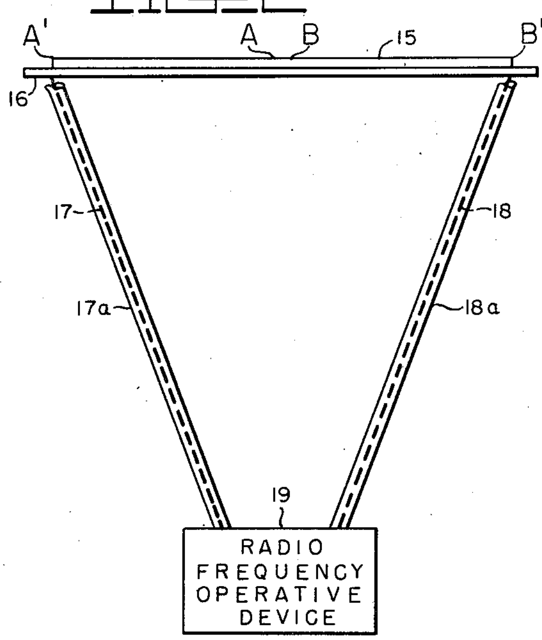


FIG-2



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LINEARLY POLARIZED SPIRAL ANTENNA SYSTEM

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to antenna systems in general and in particular to spiral antennas and feed systems therefor whereby linear polarization of the radiation from the antenna can be obtained.

The spiral antenna is a two conductor spiral wound radiator device which, although it possesses inherent features that simplify construction, possesses many desired properties that permit control of polarization and phasing in the far field. The spiral antenna as normally operated however, wherein it is fed by balanced signals at the center provides a far field which is circularly polarized. By the use of spiral doublets it is possible to employ two spiral antennas of different sense in conjunction to provide linear polarization in the far field. However there still remain instances wherein it would be desirable to obtain a linearly polarized far field with a single spiral antenna. This invention provides apparatus whereby such linear polarization can be obtained from a single spiral antenna.

It is therefore an object of the present invention to provide an antenna system employing a single spiral antenna wherein linear polarization in the far field of that spiral antenna is readily obtained.

Another object of the present invention is to provide an improved feed system for a spiral antenna which provides advantages in certain instances.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 shows a schematic view of a spiral antenna.

FIGS. 2 and 3 show spiral antenna circuits employing novel feed systems.

In accordance with the basic concepts of the present invention, a spiral antenna system is provided wherein the spiral antenna is fed or connected to the associated radio frequency operative device from the outside of the spiral conductors as well as from the conventional inside feed point.

With reference now to FIG. 1 of the drawing a schematic showing of an archimedean spiral antenna is indicated therein. As shown this antenna has an inner or starting area at the points marked A and B with substantially linear progression outward to the outer peripheral points A′ and B′, points A and A′ being located on one conductor and points B and B′ being located on a second conductor, the two conductors being relatively insulated, points A and B being at equal radius from the center and diametrically opposite positions relative to each other. Typically the assembly could be formed with a backing member of insulating material by printed circuit techniques. When such an antenna element as that shown in FIG. 1 is energized in the conventional manner solely by out of phase signals applied to the two conductors at the central points A and B, a broad circularly polarized beam is produced on each side of the flat spiral substantially perpendicular to the plane of

FIG. 1. The beam radiated from one side of the spiral exhibits circular polarization of the opposite sense from that radiated from the other side. Aside from this polarization characteristic the two radiated beams are substantially identical. In many applications it is desirable that such an antenna element radiate to one side of the spiral only. This may be accomplished by an appropriate backing of the spiral on one side by a ground plane or a cavity.

The two conductor spiral antenna behaves as a two wire transmission line which gradually by virtue of its spiral geometry transforms itself into a radiating structure or antenna. It is well known that a two wire transmission line of relatively narrow spacing yields negligible radiation when excited anti-phase at its terminals. This is due to the fact that the currents in the two wires of the line in any normal cross-section are always 180 electrical degrees out of phase so that radiation from one line is essentially cancelled by radiation from the other. Such is true if the lines are closely spaced in terms of the excitation wavelength and are of equal length. The situation is different however when a two conductor transmission line is disposed in a spiral configuration as shown in FIG. 1 and energized anti-phase by a radio frequency signal; the adjacent conductors of the spiral are then not always 180 electrical degrees out of phase. As the currents progress outward from the central point near the feed terminals A and B, the currents gradually become in-phase until at a radius which is equal to

$$\frac{\lambda}{2\pi}$$

these currents are precisely in-phase and radiation at a maximum can take place. Where a spiral is taken having a circumference greater than λ there will be inner portions where the circumference is a full wavelength for a path length difference of

$$\frac{\lambda}{2\pi}$$

for a band of frequencies rather than a single frequency. This quality makes the spiral antenna an inherently broadband device, the basic requirement being only that the maximum radius be large enough to allow a half wavelength of phase shift between the current elements on adjacent conductors at the minimum frequency of the band.

Applicants have discovered that when a spiral antenna such as that of FIG. 1 is fed from the outer terminals of the spiral conductors A′ and B′ instead of in the conventional manner at the inner terminals A and B, that substantially the same result in terms of pattern is achieved with the exception that the direction of circularity of polarization from any one side in the far field is opposite to that obtained when the spiral is fed at the center point. Further, the invention includes a combination feed arrangement which couples to the spiral antenna element from the inner terminals A and B as well as the outer terminals A′ and B′. The result of this signal combination is that the two opposite senses of polarization combine vectorially to produce linear polarization in the far field very much the same as with a spiral doublet antenna. In further similarity to the doublet antenna the direction of the linear polarization in the far field may be varied merely by rotation of the spiral antenna in the plane of FIG. 1, the angle of rotation of the plane of polarization in the far field being dependent directly upon the rotation of the spiral antenna of FIG. 1. The phase of the energy at any point in the far field may be controlled as with the spiral doublet by controlling the phase of the signals fed to the opposed pairs of terminals A, B, and A′, B′.

FIG. 2 indicates in schematic form a typical embodiment of the feed system wherein a spiral antenna is indicated in general by the portion **15** disposed upon a backing member **16** having suitable insulation and structural rigidity characteristics. The feed terminals A—B and A'—B' of the spiral antenna are indicated in FIG. 2.

In distinction from conventional connections, the outer terminals A'—B' are connected through suitable leads **17** and **18** to the radio frequency operative device **19**, which may be typically a conventional transmitter or receiver as desirmed. Leads **17** and **18** are connected in a balanced circuit, however, in the region of the terminals A' and B' they are a substantial distance apart. To prevent radiation by these leads it may be desirable in certain instances to shield them by conductive sleeves **17***a* and **18***a* or utilize some other suitable arrangement.

In the apparatus of FIG. 3, the terminals A—B and A'—B' of spiral antenna **15—16** are connected to the radio frequency operative device **19** via leads **17—18** and **20—21** and the balancing circuits **22**. The lead pairs **17—18** and **20—21** are each balanced pairs in the sense that for transmission the two members of each pair carry currents of equal amplitude and opposite polarity. The balancing circuits **22** are any suitable form of impedance matching device whereby the amplitude of the currents in the pair **17—18** may be controlled relative to the amplitude of the current in the pair **20—21**, and for additional refinement the phasing of the currents in one pair relative to the phasing of the currents in the other pair may be made adjustable by appropriate components of the balancing circuits, mechanism for such purpose being well known in the art. As a practical matter, in the normal arrangement the two pairs of leads will be equally coupled to the radio frequency operative device **19**, which means that if the device is a transmitter, half of the output power thereof will go to antenna leads A—B and half to A'—B'.

The phasing of the feed to the pair of leads **17—18** relative to the phasing of the feed to the pair of leads **20—21** is of considerable importance because as in the spiral doublet antenna, rotation of one spiral influence both the direction of linear polarization in the far field and the phase of the energy at each point in the far field.

This is ordinarily a minor matter where individual spiral antennas are used alone because the phase in the far field is then of no particular consequence and

the direction of polarization in the far field can be adjusted by rotation of the spiral. Where several spiral antennas are used together to form an array, the phasing in the far field is critical. Thus it is advantageous in many instances, but not essential that the balancing circuit **22** include adjustable phase shift apparatus.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In combination, an antenna containing two relatively insulated conductors disposed in the configuration of a planar interwound spiral having portions of different radius with the outermost portion of each conductor having substantially equal radius from the center of the spiral, a radio frequency operative device, and means coupling the radio frequency operative device to the antenna conductors at the inner and outer ends thereof simultaneously.

2. In combination, an antenna containing two relatively insulated conductors disposed in the configuration of a planar interwound spiral having portions of different radius with the outermost portion of each conductor having substantially equal radius from the center of the spiral, a radio frequency operative device, means coupling the radio frequency operative device to the antenna conductors at the inner end outer ends thereof, and means for controlling the relationship of the coupling of the inner and outer ends to the radio frequency operative device.

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