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POLARIZATION DIVERSITY WITH FLAT SPIRAL ANTENNAS

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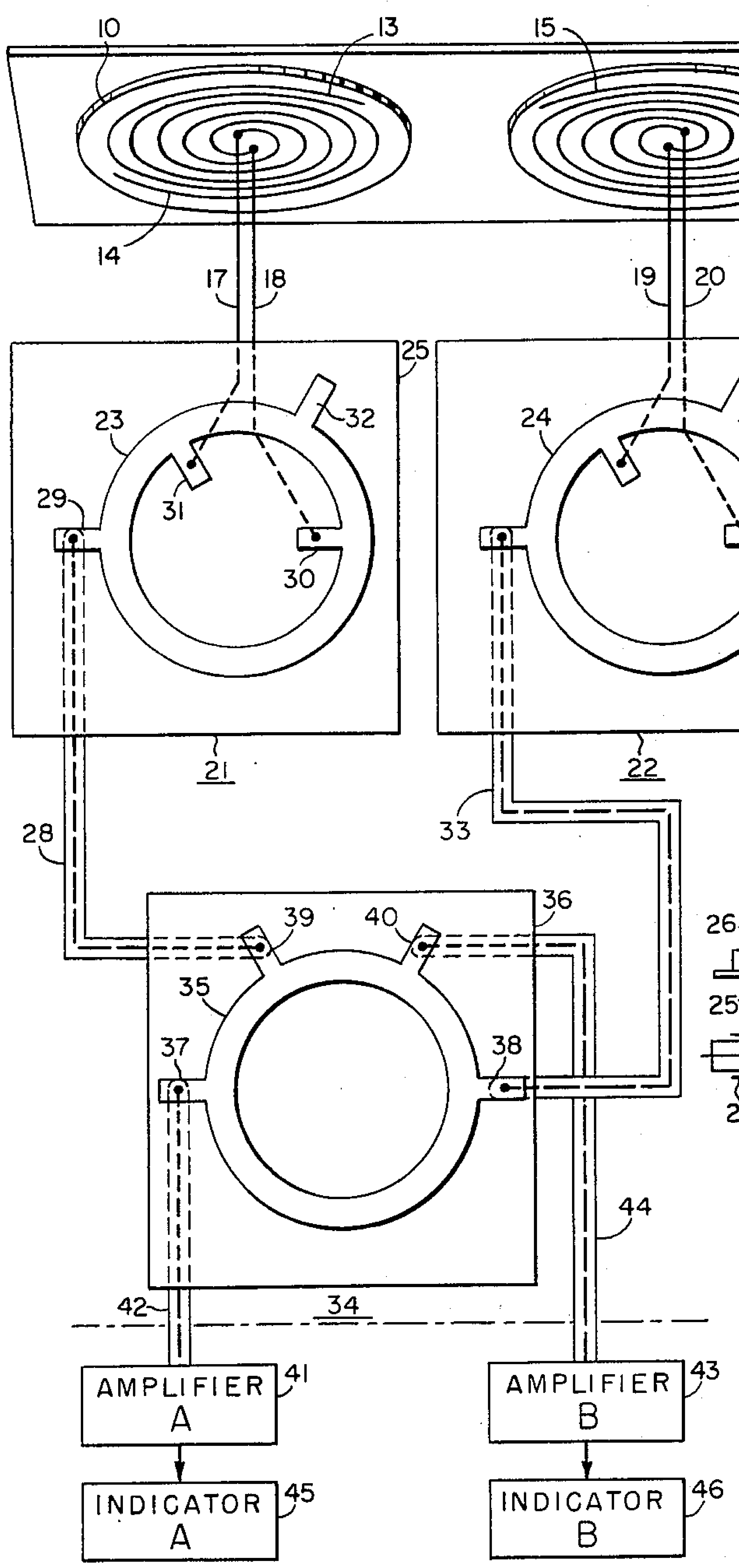


FIG. 1

FIG. 2

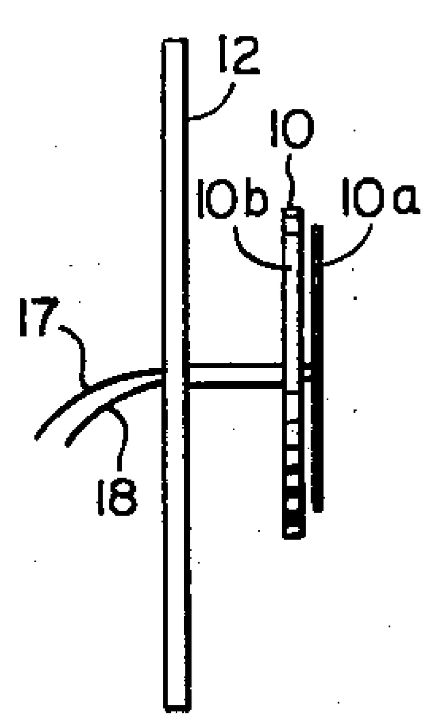


FIG. 3

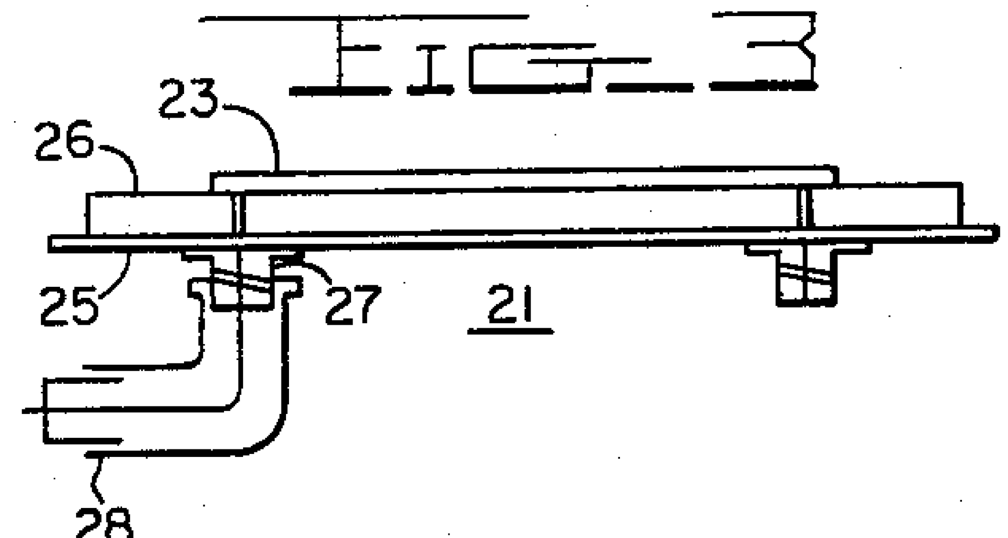
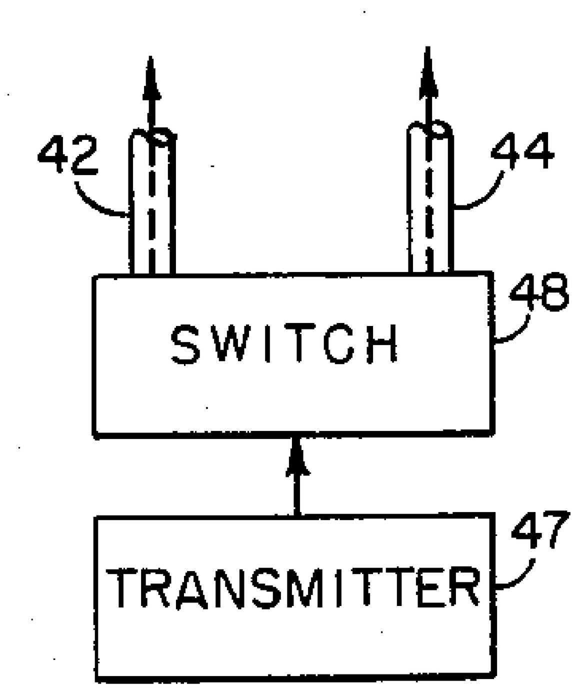


FIG. 4



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POLARIZATION DIVERSITY WITH FLAT SPIRAL ANTENNAS

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6 Claims. (Cl. 343—100)

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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 feed systems capable of enhancing unique properties of spiral antenna systems.

When two spiral antenna elements are disposed in such relationship that the normal circular polarization from each are of opposite sense, the resulting combination has unique properties which in many instances are highly desirable. For example, such an antenna can produce a combined field which is linearly polarized and in which the direction of polarization as well as the phase of the energy at any point in the far field is readily adjustable. Such adjustment is accomplished without any serious complication of any sort merely by rotating the spiral antennas according to well-known principles. Although the spiral antenna can thus produce or respond to polarization at any angle merely by the proper adjustment thereof, the existence of artificial as well as natural objects which predominate in either the vertical plane or the horizontal plane relative to the earth makes the operation of devices such as radar systems at one or the other of the two limiting conditions of polarization more desirable. Thus there are many instances in which it would be desired to operate at one or the other condition of vertical or horizontal polarization without any particular requirement for operation at intermediate positions. Similarly it may be desired to resolve a single received signal into the components in the vertically polarized plane.

Accordingly, it is an object of the present invention to provide an antenna feed system for a spiral antenna system wherein the antennas are coupled to the utilization device associated therewith in such a manner as to provide for selection of operation to obtain either horizontal or vertical polarization independently or coincidentally.

Another object of the present invention is to provide apparatus for matching a spiral doublet form of antenna to a utilization device in such manner as to obtain the linear polarization possible from the spiral doublet antenna.

Another object of the present invention is to provide an antenna coupling system whereby the horizontally and vertically polarized signals may be obtained at separate utilization channels.

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 typical embodiment of the features of the present invention as applied to a dual channel receiver system wherein the horizontal and vertical signals are directed into two separate channels.

Fig. 2 indicates in a side view the general arrangement of the individual spiral antenna elements in proximity to a reflector device.

Fig. 3 indicates in general the method of connection of leads to the various signal resolving devices employed in the apparatus of Fig. 1.

Fig. 4 indicates in general the method of connection of a transmitter to the apparatus of Fig. 1 whereby energy may be controllably emitted with either horizontal or vertical polarization.

In accordance with the basic teachings of the present invention a plurality of hybrid junctions are disposed in a novel combination which provides between a plurality of spiral antenna elements constituting a spiral doublet and a suitable utilization device such as a transmitter or a receiver, signal energy balancing, phasing, and division to provide resolution of input electrical energy into selected polarization components or to produce output electrical energy having a selected polarization plane.

With reference now to Fig. 1, the apparatus shown therein contains first and second spiral antenna elements **10** and **11** of mutually opposite configuration sense which are mounted in proximity to each other and to a ground plane or reflector **12**. The arrangement of these component parts is indicated in somewhat greater detail in the side view of Fig. 2 which clearly shows the antenna element **10** and the reflector **12**. The spiral antenna elements are typically linear or Archimedean spirals of two conductors from a small central radius to a larger outer radius, the conductors being further typified herein as printed circuit conductors mounted upon a base member of insulating material. The conductors are indicated in Fig. 2 by the numeral **10*a*** and the base member of insulating material by the numeral **10*b***. Connection of the spiral conductors **10*a*** to external utilization circuits is indicated by the lines **17**, **18** which are also shown in Fig. 1. Fig. 1 indicates with separate numerals the two conductors **13**, **14** and **15**, **16** of the two spiral elements showing the connections thereof by the balanced transmission lines of wires **17—18** and **19—20** to balanced to unbalanced converters **21** and **22**. The balanced to unbalanced converters **21** and **22** are basically hybrid junction devices formed of a strip type conductor separated from a backing plate with additional detail thereof being shown in Fig. 3 for the typical converter **21** showing the strip conductor **23**, the backing plate **25**, separator of insulating material **26**, and a typical coaxial connector **27** by means of which coaxial cable leads **28** are connected to the strip conductor **23**. The typical strip conductor **23** is a circular member having a rectangular cross section the effective circumference of the circular portion being one and a half wavelengths with diametrically opposed taps **29**, **30** and intermediate taps **31** and **32** disposed at quarter wavelength spacing relative to the taps **29** and **30**. For convenience in making the connections to lines **17** and **18** the taps **30** and **31** are inwardly extending whereas the tap **29** is outwardly extended. Tap **32** in this instance is not used.

The balanced to unbalanced converters **21** and **22** are connected by means of coaxial cables **28** and **33** to the power control device **34** which, like the balanced to unbalanced converters, is a device having a strip conductor **35** mounted in proximity to a backing plate **36** and spaced therefrom by a suitable insulating member such as that identified by the numeral **26** in Fig. 3 for the balanced to unbalanced converter **21**. Also like the balanced to unbalanced converter, the device **34** has connections thereto made by means of the coaxial cables, with the strip type conductor **35** also being in the form of a circle having a rectangular cross-section with an overall effective circumferential length of one and one half wavelengths, taps **37** and **38** disposed at diametrically opposed points on the conductor **35** and intermediate taps **39** and **40** located at points spaced from the taps **37** and **38** by an effective quarter wavelength. Taps 39 and 40 thus are also effectively one quarter wavelength apart.

Tap 37 is connected to amplifier 41 by means of coaxial cable 42 whereas amplifier 43 is connected to tap 40 by means of a coaxial cable 44. Each amplifier 41 and 43 has some suitable form of indicator 45, 46 connected thereto by means of which suitable indication or storage of the output signals from the amplifiers can be obtained.

Fig. 4 shows an arrangement whereby a single transmitter 47 can be connected through a suitable switch 48 which may be simply a double throw switch to the lines 42 and 43 so that transmitter energy may be delivered to the device 34 through either line 42 or 44 for the purposes which will be explained in detail in the subsequent description of the operation of the apparatus.

In operation of the circuit consideration of basic principles of spiral antenna elements and in particular the spiral doublet form of antenna will be helpful. Such an antenna element provides basically circular polarization coupling to the far field however when such an antenna is used in groups of two having opposite far field polarization direction, linear polarization results, with it being possible to vary the direction of the linearity of polarization merely by rotating the spiral antenna elements. Thus it is possible to achieve linear polarization in any desired plane by appropriate coupling to the elements followed by a careful orientation of the elements to achieve the result desired. When such a condition exists, a reversal of the phase of excitation of one spiral antenna element relative to that of the other effectively achieves a condition wherein the plane of polarization of the coupling to the far field is rotated through an angle of 90°. Thus one condition can be that corresponding to horizontally polarized energy whereas the reverse corresponds to vertically polarized energy.

The device 34 provides just such operation, amplifier 41 being connected to terminal 37 which by means of the specific arrangement of the hybrid junction, couples to terminal 39 with 180° difference in phasing of energy at terminal 38. On the other hand, amplifier 43 is connected to terminal 40 which is a quarter wavelength away from both terminals 39 and 38 and hence provides these terminals with coupling in such a manner that they are operative in phase. The resultant of such an arrangement is that the amplifier 41 and the amplifier 43 are effectively connected to the antennas 10 and 11 in such a manner that one amplifier receives horizontally polarized waves incident upon the antenna elements 10 and 11 whereas the other amplifier receives vertically polarized waves incident upon the antennas 10 and 11.

The balanced to unbalanced converters 21 and 22 provide for conversion of the unbalanced arrangement of the coaxial cables 28 and 33 to the balanced arrangement desired for better operation of the spiral antenna elements 10 and 11.

While the basic apparatus of Fig. 1 is a receiving system capable of simultaneously monitoring signals received in two orthogonally related planes of polarization, the modification indicated by Fig. 4 permits the emission of energy in one or the other of the planes of polarization as controlled by switch 48. Thus typically it is possible to emit energy having either a horizontal polarization or a vertical polarization as desired.

The hybrid junctions which form the basic components 21, 22 and 34 are designed to obtain a 70 ohm characteristic impedance in the circular or ring portion and a 50 ohm characteristic impedance in the terminal portions 29, 32, 31 for example. Such dimensions may be readily obtained with the circular portions of the conductors 2 millimeters wide, the terminal portions 3.6 millimeters wide, the strip conductor separated from the base member by an amount of 1.6 millimeters, and the circular portions of the strip conductor having a mean diameter of 78 millimeters.

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, first and second spiral antenna elements, means mounting said antenna elements in a doublet whereby each independently has circularly polarized coupling to free space, the coupling from the two elements however being in opposite polarization sense, first and second coupling utilization channels, and means for connecting said coupling utilization channels to said antenna elements whereby one channel is connected to the elements with a different phase difference between the elements from the connection of the other channel to the elements.

2. In combination, first and second spiral antenna elements, means mounting said antenna elements in a doublet whereby each has circularly polarized coupling to free space wherein the elements produce coupling of opposite polarization sense, first and second coupling utilization channels, and means for connecting said coupling utilization channels to said antenna elements whereby one channel is connected to the elements with a 180° phase difference between the elements relative to that for the connection of the other channel to the elements.

3. In combination, first and second spiral antenna elements, means mounting said antenna elements in a doublet whereby each has circularly polarized coupling to free space, the two elements having opposite polarization sense coupling, first and second coupling utilization channels, and means including a hybrid junction for connecting said coupling utilization channels to said antenna elements whereby one channel is connected to the elements with a different phase difference between the elements from the connection of the other channel to the elements.

4. In combination, first and second spiral antenna elements, means mounting said antenna elements in a doublet whereby each has circularly polarized coupling to free space, the two elements having coupling of opposite polarization sense, first and second coupling utilization channels, and means including a hybrid junction for connecting said coupling utilization channels to said antenna elements whereby one channel is connected to the elements with a 180° different phase relationship between the elements from the connection of the other channel to the elements.

5. In combination, first and second spiral antenna elements, means mounting said antenna elements in a doublet whereby each has circularly polarized coupling to free space, the two elements having coupling of opposite polarization sense, first and second coupling utilization channels, and means for coupling said channels to said elements whereby one channel couples to the two elements with an in-phase relationship and the other channel couples to the elements with a 180° phase relationship.

6. In combination, first and second spiral antenna elements, means mounting said antenna elements in a doublet whereby each has circularly polarized coupling to free space, the two elements producing coupling of opposite polarization sense, first and second coupling utilization channels, a balanced to unbalanced converter for each element whereby the leads to the elements are balanced, and means for connecting said coupling utilization channels to the unbalanced portion of the balanced to unbalanced converters whereby one channel is connected to the antenna elements with a different phase difference between the antenna elements from the connection of the other channel to the antenna elements.

No references cited.