

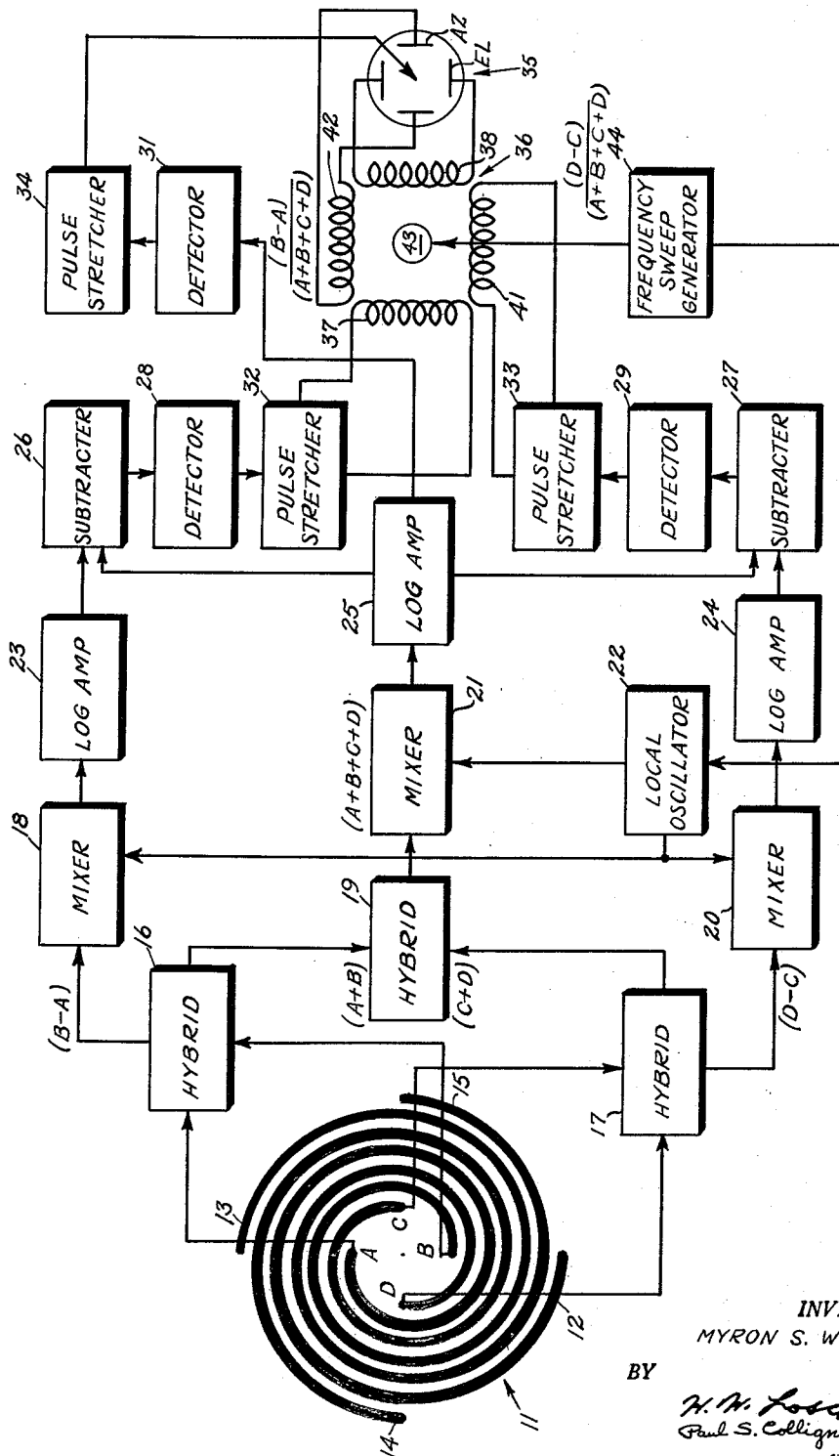
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M. S. WHEELER

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PASSIVE DIRECTION-FINDER SYSTEM

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INVENTOR.
MYRON S. WHEELER
BY
H. M. Losche
Paul S. Collignon
ATTORNEYS

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PASSIVE DIRECTION-FINDER SYSTEM

Myron S. Wheeler, Baltimore, Md., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy
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The present invention relates to a broadband radio direction-finding system and more particularly to a direction-finding system employing a four arm spiral antenna.

One heretofore known passive direction-finding system employs a cluster of four horn-type receivers that are paired to give amplitude comparison in azimuth and elevation. These horn antennas are expensive and furthermore, do not have the advantage of being flush mounted like a spiral antenna. In addition, spiral antennas have the desirable feature of constant beam width, which the horns do not have.

The spiral antenna used in the present invention has four spiral conductors disposed in a single plane with separate feed means being provided for each conductor. When the four arms of the spiral antenna are driven at 0 degrees, 90 degrees, 180 degrees, and 270 degrees relative phase, an on-center circularly polarized beam is produced. Phase shifting two opposite arms antisymmetrically relative to the other two arms produces a deflection of the beam in one axis and phase shifting the other two arms deflects the beam on the other axis. No specific direction of deflection is associated with a specific pair of input feed lines because the nature of a spiral antenna is such that a given deflection, produced by phase shifts in one pair of inputs, rotates with the applied signal frequency. That is, the spirals radiate principally from a traveling wave on an equivalent ring which is one wavelength in circumference and in the plane of the spiral. As the conducting arms tie into this mathematically symbolic ring at different rotational points, depending upon the applied frequency, the effect of phase shifts in a particular pair of feeds is rotated with respect to their position at the center of the antenna. Thus, at any one frequency, a pair of feed points may be made by design as azimuth. The other pair of feed points are automatically 90 degrees with respect to the first pair and would be elevation.

The necessary phase shifts for the four spiral arms, which need be fed at 0 degrees, 90 degrees, 180 degrees, and 270 degrees, respectively, may be provided by magic T-like hybrids providing inherent 180 degree phase differences and one coaxial or strip line hybrid having inherent 90 degree phase differences between the output arms.

The derived elevation and azimuth are displayed on a C-scope with Z-axis brightening during the presence of targets. A coordinate rotation converter is provided in order to compensate for the rotation of the antenna electrical co-ordinate system with frequency. A frequency sweep generator is provided to tune the system through its design band and this frequency sweep generator also rotates the co-ordinate converter simultaneously, thus resulting in a true C-scope display in spite of the rotational characteristic of the spiral antenna.

It is therefore an object of the present invention to provide an improved passive direction-finder system.

Another object of the present invention is to provide an improved direction-finder system having a spiral antenna.

Other objects and advantages of the present 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 drawing.

The drawing is a schematic diagram showing an embodiment of the present invention.

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Referring now to the drawing, there is shown an antenna 11 having four spiral conductors 12, 13, 14, and 15, with feed points A, B, C, and D, respectively. Feed points A and B are connected to waveguide hybrid 16, and feed points C and D are connected to waveguide hybrid 17. Waveguide hybrids 16 and 17 are of the type having magic T-like phase shift properties and are well-known in the art. One output of the hybrid 16 is fed into a first channel, which might be designated in an elevation error channel, and one output of hybrid 17 is fed into a second channel, which might be designated as an azimuth error channel. A second output of hybrid 16 and also a second output of hybrid 17 is fed into a third channel, which is designated as a sum channel.

As can be seen in the figure of the drawing, hybrid 16 feeds mixer 18 and hybrid 19, and hybrid 17 feeds mixer 20 and hybrid 19. Hybrid 19 is of the type having coaxial-type hybrid phase shift properties. The output of hybrid 19 is fed into mixer 21. A local oscillator 22 provides a signal for each of the mixers 18, 20, and 21, and the output of the mixers are amplified by broadband logarithmic amplifiers 23, 24, and 25, respectively.

The outputs of amplifiers 23 and 25 are fed into a first subtracter 26 and the sum channel signal is subtracted from the elevation error signal in order to normalize the elevation error signal. As a difference of logarithms is a ratio, the output of subtracter 26 is:

$$\frac{(B-A)}{(A+B+C+D)}$$

Likewise, the outputs of amplifiers 24 and 25 are fed into a second subtracter 27 and the sum channel signal is subtracted from the azimuth error signal in order to normalize the azimuth error signal. The output of subtracter 27 is:

$$\frac{(D-C)}{(A+B+C+D)}$$

The outputs of subtracters 26 and 27 are applied to detectors 28 and 29, respectively, in order to obtain a video envelope, and likewise an output of amplifier 25 is applied to detector 31. The pulses provided by detectors 28, 29, and 31, are lengthened by pulse stretchers 32, 33, and 34, respectively, in order to give more duration to the signals for presentation to a C-scope 35.

The elevation error signal and azimuth error signal are applied to a co-ordinate rotation converter 36 which performs the following operations:

(1)

$$\text{Elevation error} = \frac{(D-C)}{(A+B+C+D)} \sin \phi$$

$$+ \frac{(B-A)}{(A+B+C+D)} \cos \phi$$

and

(2)

$$\text{Azimuth error} = \frac{(D-C)}{(A+B+C+D)} \cos \phi$$

$$- \frac{(B-A)}{(A+B+C+D)} \sin \phi$$

where angle ϕ is a characteristic of the antenna, having a known rate of change with respect to frequency.

The co-ordinate rotation converter 36 is comprised of two elevation coils 37 and 38 and two azimuth coils 41 and 42. Elevation coil 37 is connected to pulse stretcher 32 and azimuth coil 41 is connected to pulse stretcher 33. Coils 38 and 42 are connected to C-scope 35. A rotor 43 is positioned in the center of the four coils and is rotated by the frequency sweep generator 44. The function of the co-ordinate rotation converter 36 is to compensate for the

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rotation, with frequency, of the antenna electrical co-ordinate system. The frequency sweep generator 44 tunes the system through its design band and rotates the co-ordinate converter simultaneously, resulting in a true C-scope display in spite of the characteristic of the antenna to rotate.

In operation, when the four arms of the spiral antenna 11 are driven at 0, 90, 180, and 270 degrees relative phase, an on-center, circularly polarized beam is produced. Opposite arms of the antenna are paired and phase shifted to produce deflections in both the azimuth and elevation directions. Hybrids 16 and 17, which have magic T-like phase shift properties, and hybrid 19, which has coaxial type hybrid phase shift properties, are provided to accomplish the desired phase shifting. The antenna output is introduced into three separate channels, namely, an elevation error channel, an azimuth error channel, and a sum channel. The incoming signal is heterodyned in the mixers 18, 20, and 21, and amplified by broadband logarithmic I-F amplifiers. The sum channel signal is then subtracted from the elevation error signal and the azimuth error signal in subtractors 26 and 27, respectively. The two error channel signals are then introduced into the co-ordinate rotation converter 36 which compensates for the rotation, with frequency, of the antenna electrical co-ordinate system. The derived elevation and azimuth are then displayed on C-scope 35, which has the display brightened during the pulse period.

It can thus be seen that the present invention provides an improved direction-finder system having a spiral antenna.

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. A passive direction finding system comprising: a spiral antenna having first and second pairs of arms, an azimuth error channel connected to said first pair of arms, an elevation error channel connected to said second pair of arms, a sum channel connected to both said first and second pairs of arms, first means for subtracting a signal in said sum channel from a signal in said azimuth error channel, second means for subtracting a signal in said sum channel from a signal in said elevation error channel, means for visually displaying the derived azimuth and elevation signals, and means for compensating for the rotation with frequency of the electrical co-ordinate system of said spiral antenna.

2. A passive direction finding system as set forth in claim 1 wherein said azimuth error channel and said elevation error channel each include a hybrid having magic T-like phase shift properties.

3. A passive direction finding system comprising: a spiral antenna having first and second pairs of arms; an azimuth error channel connected to said first pair of

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arms, said channel comprising a hybrid, a mixer, and a logarithmic amplifier; an elevation error channel connected to said second pair of arms, said channel comprising a hybrid, a mixer, and a logarithmic amplifier; a sum channel connected to both said first and second pairs of arms, said sum channel comprising a hybrid, a mixer, and a logarithmic amplifier; first means for subtracting a signal in said sum channel from a signal in said azimuth error channel; second means for subtracting a signal in said sum channel from a signal in said elevation error channel; means for visually displaying the derived azimuth and elevation signals; and means for compensating for the rotation with frequency of the electrical co-ordinate system of said spiral antenna.

4. A passive direction finding system as set forth in claim 3 wherein said hybrid in said azimuth error channel and said hybrid in said elevation error channel have magic T-like phase shift properties.

5. A passive direction finding system as set forth in claim 3 wherein said hybrid in said sum channel has coaxial type phase shift properties.

6. A passive direction finding system comprising: a spiral antenna having first and second pairs of arms; an azimuth error channel connected to said first pair of arms, said channel comprising a hybrid, a mixer, and a logarithmic amplifier; an elevation error channel connected to said second pair of arms, said channel comprising a hybrid, a mixer, and logarithmic amplifier; a sum channel connected to both said first and second pairs of arms, said sum channel comprising a hybrid, a mixer, and a logarithmic amplifier; a first subtractor connected to said azimuth error channel and said sum channel for subtracting a signal in said sum channel from a signal in said azimuth error channel; a second subtractor connected to said elevation error channel and said sum channel for subtracting a signal in said sum channel from a signal in said elevation error channel; means for visually displaying the derived azimuth and elevation signals; and a co-ordinate rotation converter for compensating for the rotation with frequency of the electrical co-ordinate system of said spiral antenna.

7. A passive direction finding system as set forth in claim 6 wherein said hybrid in said azimuth error channel and said hybrid in said elevation error channel have magic T-like phase shift properties.

8. A passive direction finding system as set forth in claim 6 wherein said hybrid in said sum channel has coaxial type phase shift properties.

References Cited in the file of this patent

UNITED STATES PATENTS

2,990,548 Wheeler ----- June 27, 1961

OTHER REFERENCES

Aviation Week, Nov. 17, 1958, pp. 75, 77. Copy in Scientific Library.