

United States Patent [19]

[11] 3,829,863

Lipsky

[45] **Aug. 13, 1974**

- [54] **POLARIZING FEED APPARATUS FOR
BICONICAL ANTENNAS**
- [75] Inventor: **Stephen E. Lipsky**, East Hills, N.Y.
- [73] Assignee: **General Instrument Corporation**,
Newark, N.J.
- [22] Filed: **Mar. 12, 1973**
- [21] Appl. No.: **340,322**

- [52] U.S. Cl..... 343/773, 343/726, 343/756
[51] Int. Cl. H01q 13/00, H01q 19/00, H01q 21/00
[58] Field of Search..... 343/773, 726, 756

[56] **References Cited**

UNITED STATES PATENTS

- 2,532,428 12/1950 Smith..... 343/756

OTHER PUBLICATIONS

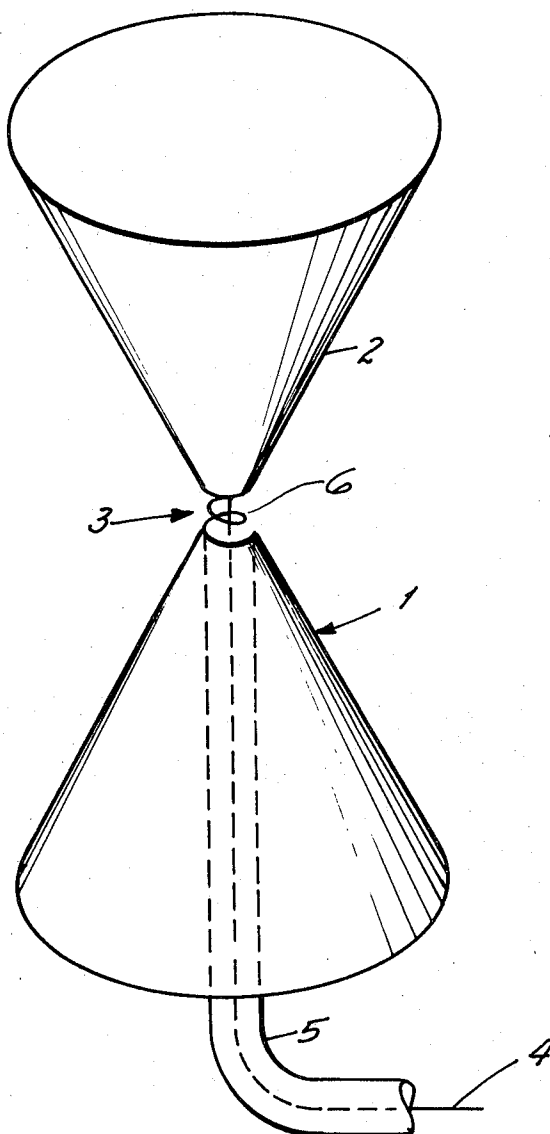
Southworth, Principles and Applications of Waveguide Transmission, Aug. 1950, pp. 419-420

Primary Examiner—James W. Lawrence
Assistant Examiner—T. N. Grigsby

[57] **ABSTRACT**

Apparatus is disclosed for feeding a single biconical antenna of the type having an upper and a lower cone which are connected to a coaxial feed line, the apices of said cones being in close proximity. The apparatus comprises means for vertically feeding said antenna, the vertical feed means being located at the apices of the cones. Means are also provided for horizontally feeding the antenna, the horizontal feed means being located in the vicinity of the apices of said cones. This combination of feed apparatuses permits the utilization of the vertical, horizontal, slant linear and circular polarization without the necessity of an external polarizer.

12 Claims, 5 Drawing Figures



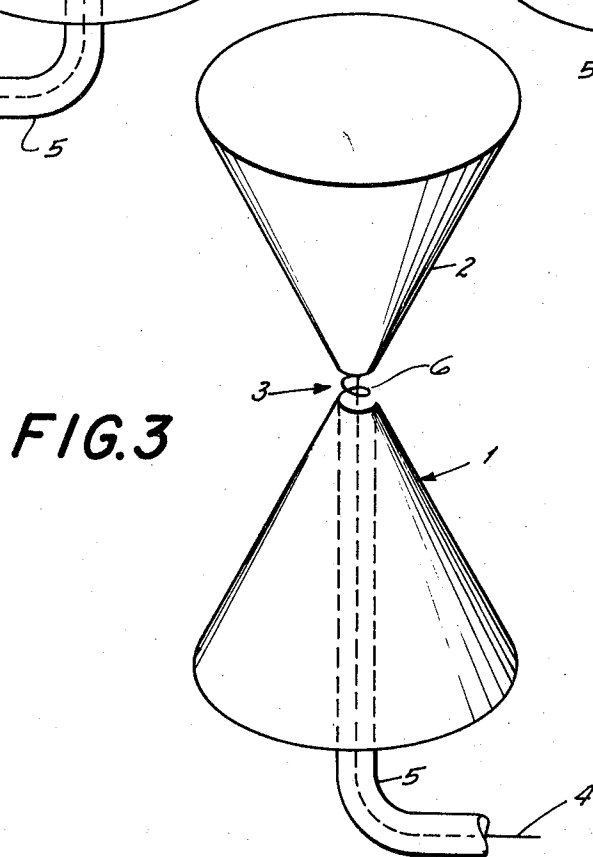
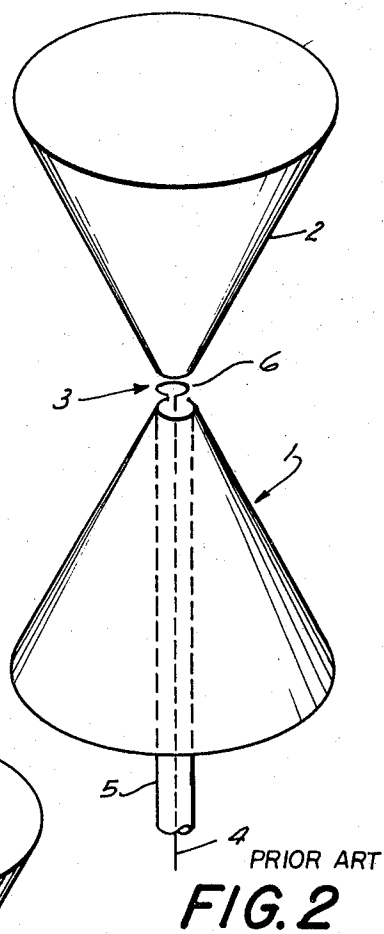
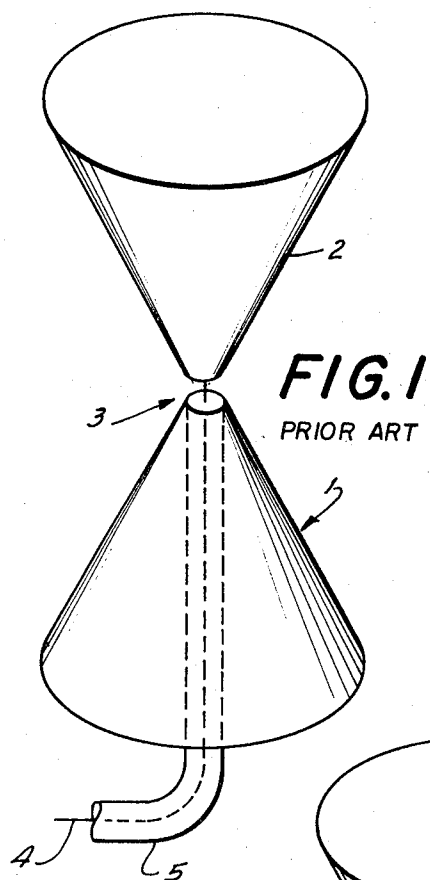


FIG. 4

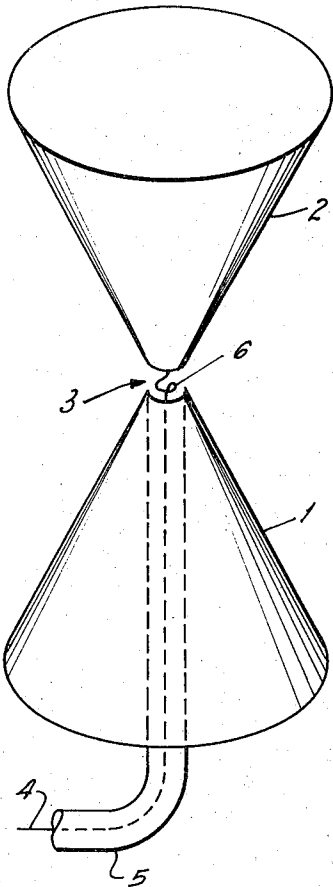
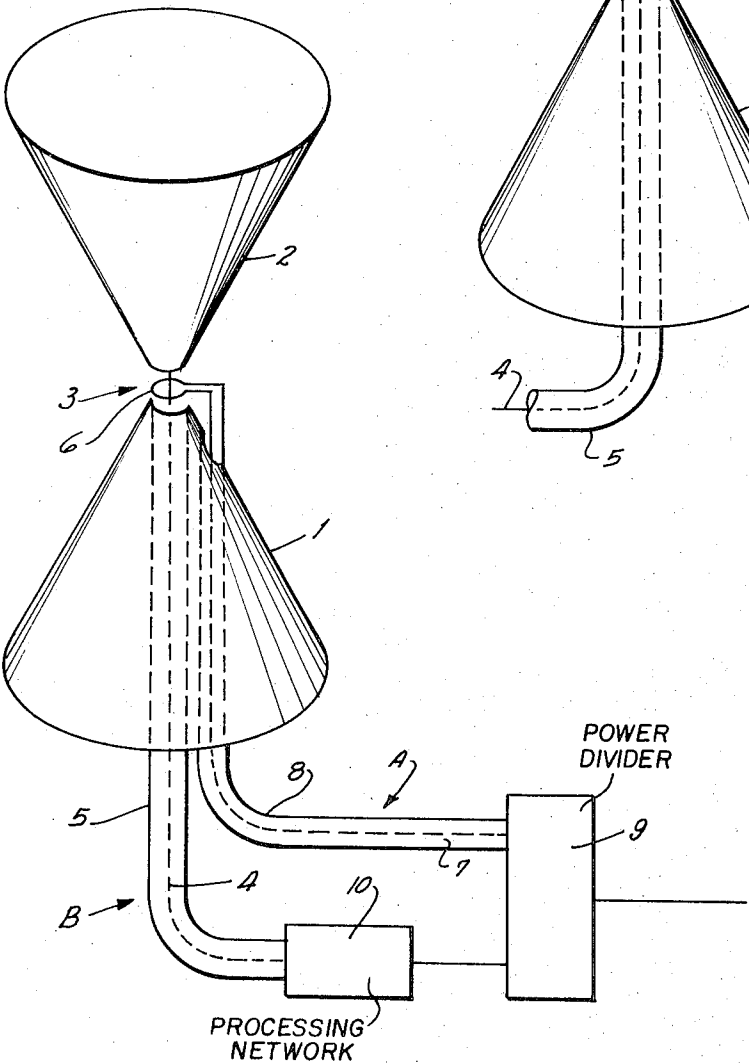


FIG. 5



POLARIZING FEED APPARATUS FOR BICONICAL ANTENNAS

The present invention relates to feed apparatus for biconical antennas and more particularly to method and apparatus for feeding a biconical antenna which permits the reception or transmission of waves of any polarization, including slant, linear or circularly polarized waves, without the need for conventional polarizers normally employed for this purpose.

The biconical antenna is capable of providing a uniform omnizimuthal pattern over a frequency range exceeding an octave. Because of this feature, biconical antennas have proved useful in a number of applications, particularly those having to do with reconnaissance. However, it was not previously known how to construct a biconical antenna which could be utilized with polarizations of all orientations without physical reorientation of the antenna. Prior art attempts to overcome this problem have normally been accomplished through the use of an external polarizer fitted about the antenna or within the throat of the bicone itself. Such polarizers were necessary because the feed apparatuses previously available for use with biconical antennas have been able to produce only either vertical or horizontal polarization. Due to this deficiency, the encumbrance and limitations inherent in the use of external polarizers were deemed unavoidable.

Two principal types of polarizers are currently being used with biconical antennas. Both of these types of polarizers consist of a series of concentric cylinders having parallel wires arranged on the surface of each cylinder. The angle which the wires make with one axis of the bicone increases for each successive cylinder. Normally, the wires are produced by printed circuit techniques and are separated and supported by a low loss rigid foam structure. The basic principle of operation for both types of polarizers is identical. Either a vertical or horizontal feed structure is used in the biconical antenna. For example, consider a biconical antenna which is vertically fed. Ideally, the polarizer will permit vertically polarized waves to pass through the feed structure unhampered. Horizontally polarized waves will be redirected through the polarizer and emerge as vertically polarized waves at the feed. In this way either polarization is received by the vertical polarized feed as a vertically polarized wave.

In the first type of polarizer, the printed wires are resonant at the frequency of the signal. When a vertical feed structure is employed, a horizontal wave is received by the first set of wires located on the outermost cylinder. These wires are offset from the horizontal by a small angle. The wires of this cylinder accept a component of the horizontal field and reradiate it at the offset angle. The wires on the next successive concentric cylinder are offset at a greater angle from horizontal, but are at a relatively small offset angle with respect to the set of wires on the first concentric cylinder. The set of wires on the second concentric cylinder accepts the wave reradiated from the first concentric cylinder and in turn reradiates this energy with the polarization determined by its own offset angle. Each successive set of wires on each successive concentric cylinder progressively shifts the polarization until it is vertically polarized and can be accepted by the feed. It can be seen from the resonant character of the wires used, that this type of polarizer is frequency sensitive.

The second type of polarizer is not as frequency sensitive as the one previously described. In this type of polarizer, the ends of the wires are grounded at the top and bottom of the polarizer to form the boundary of a twisted guide. Again using the vertical feed as an example, the set of wires on the first concentric cylinder will be offset from the vertical axis by a small angle (as opposed to the horizontal axis with the resonant polarizers previously described). The offset angle of each successive set of wires on each successive concentric cylinder is increased to form a twisted guide which will duct a horizontally polarized wave received at the outside cylinder of the polarizer to the feed as a vertically polarized wave.

Although the second type of polarizer is not as frequency sensitive as the first, it is frequency limited and represents a significant design problem if greater than octave frequency coverage is desired. Both polarizers normally represent a loss in antenna efficiency, an increase in antenna size and greater development and production costs. The present invention relates to methods whereby the external polarizer can be eliminated through a novel design of feed apparatus.

It is therefore a prime object of the present invention to provide a feed apparatus for a biconical antenna which will simultaneously accept vertical and horizontal polarization without physical reorientation of the antenna and without the necessity of an external polarizer.

It is a further object of the present invention to provide a feed apparatus for a biconical antenna which will accept slant linear polarization as well as circular polarization without the necessity for an external polarizer.

In accordance with the present invention, apparatus is provided for feeding a single biconical antenna of the type having an upper and lower cone which are connected to a coaxial feed line and in which the apices of said cones are in close proximity. A means for vertically feeding the antenna is located at the apices of the cones. Means for horizontally feeding the antenna is additionally provided, the horizontal feed means being located in the vicinity of the apices of the cones. The combination of a vertical feed apparatus and a horizontal feed apparatus in a single biconical antenna permits the generation and reception of horizontal, vertical, slant linear and circular polarizations simultaneously in the same antenna structure without the necessity of external polarizing mechanisms.

The results obtained through the use of the method and apparatus disclosed herein are achieved through the use of separate vertical and horizontal feed apparatuses used in combination. Three separate methods of combining the vertical and horizontal feed apparatuses in a biconical antenna are herein described for purposes of illustration. The first and third embodiments of the present invention disclosed herein exemplify two parallel type combinations for the vertical and horizontal feed apparatus. The second embodiment exemplifies a form of series combination which can be used to achieve the desired results.

The drawings, which form a part of this application, illustrate several preferred embodiments of the present invention wherein like numerals are used to refer to like parts.

FIG. 1 is a plan view of a typical biconical antenna with a vertical feed apparatus.

FIG. 2 is a plan view of a typical biconical antenna with a horizontal feed apparatus.

FIG. 3 is a plan view of the first embodiment of the present invention showing a horizontal feed loop connected in parallel with the vertical feed apparatus.

FIG. 4 is a plan view of the second embodiment of the present invention showing a horizontal feed loop in series with the vertical feed apparatus in a biconical antenna.

FIG. 5 is a plan view of a third embodiment of the present invention wherein two feed lines are utilized, one of which feeds the horizontal loop and the other which feeds the vertical feed apparatus in a parallel configuration.

FIG. 1 illustrates a vertical feed structure for a biconical antenna. The typical biconical antenna comprises two cones, a lower cone, designated as 1, and an upper cone designated as 2. The apices of lower cone 1 and upper cone 2 are in close proximity in the throat area 3 of the biconical antenna. For purposes of better illustrating the feed structures shown in these drawings, the throat portion 3 of each of the biconical antennas which appear in the drawings has been slightly extended. The biconical antenna in FIG. 1 is fed by a coaxial feed line consisting of an outer conductor 5 and an inner conductor 4. The outer conductor 5 is operably connected to the lower cone 1 and the inner conductor 4 extends through the throat portion 3 and is operably connected to the upper cone 2. This is the typical configuration for a vertically fed biconical antenna.

The field of the TEM mode in the coaxial feed lines extends radially from the outer conductor to the inner conductor. As the wave propagates beyond the coaxial feed to the throat and then to the cones of the antenna, it emerges as a vertically polarized wave with the field extending from the lower cone to the upper cone. When used in this way, the bicones can be viewed as extensions of the coaxial feed line, the upper and lower cones serving as matching extensions to free space for the inner and outer conductors respectively.

In FIG. 2 apparatus for generating a horizontal polarization in a biconical antenna is shown. The means for generating horizontal polarization in the antenna is preferably in the form of a horizontal loop 6 located in the throat portion 3 of the biconical antenna. This horizontal loop 6 is actively fed by the coaxial feed line, one conductor of which is operably connected to each end of the loop 6.

FIG. 3 illustrates the combination of a vertical and horizontal polarization feed apparatus connected in a parallel combination in a single biconical antenna. In this embodiment the inner coaxial conductor 4 of the feed line is connected to supply the horizontal loop 6 as well as the upper cone 3. The horizontal loop 6 is connected between the inner conductor 4 and the lower cone 1. The design of the vertical and horizontal feeds and the matching sections are such that energy and phase division between the vertical and horizontal modes of energy in the bicone can be controlled. If, at a particular frequency, a 90° phase difference between equal horizontal and vertical waves exists in the bicone, circular polarization will result. The feed networks are designed to achieve this difference by their design and by the division of energy in each feed.

FIG. 4 illustrates a second embodiment of the present invention wherein the vertical and horizontal feed ap-

paratus are connected in series. The horizontal loop 6 is preferably connected in series with the inner conductor 4 of the coaxial feed line which feeds the upper cone 3. The loop 6, illustrated in this embodiment, can be in the form of a spiral or a horizontal loop similar to that shown in FIG. 3. The energy division between the vertical and horizontal mode is determined by the effective radiation resistance of the loop 6 and the vertical feed to the bicone. For equal power division, the radiation resistances of each mode should be equal. These resistances are controlled, in part, by the design of the antenna and feed elements and by the matching impedance of the loop 6. The actual design parameters will be chosen to optimize the polarization effects desired. The same factors, including the phase shift and wave propagation, which affect the design of the parallel mode, shown in FIG. 3 and described above, would affect the design of the series mode configuration shown in FIG. 4.

FIG. 5 illustrates a third embodiment of the present invention. In this embodiment two separate coaxial feed lines are utilized to feed the vertical and horizontal feed apparatuses, respectively. A power divider 9 is used to divide the input power between the two coaxial feed lines, generally designated as A and B, respectively. Feed line A consists of an inner conductor 7 and outer conductor 8, each of which is connected to a different end of horizontal loop 6 located in the throat portion 3 of the bicone. The second output of power divider 9 is fed to a processing network 10, the output of which feeds the second coaxial feed line B. Coaxial feed line B is comprised of an inner conductor 4 and an outer conductor 5. The outer conductor 5 is operably connected to the lower cone 1 and the inner conductor 4 is operably connected to the upper cone 3 thus forming the vertical polarization feed apparatus. The processing network 10 can be utilized to supply several functions, including phase and amplitude variation with frequency. This type of network need not be restricted to only one feed line but may be placed at either or both lines, as necessary. Similarly, the power divider 9 need not be restricted to equal power division.

The external circuitry shown in FIG. 5 as a power divider 9 and a processing network 10 can provide great flexibility in the performance which can be obtained from a biconical antenna. A lower radiation efficiency or an undesired phase shift from either feed apparatus can be compensated for in this circuitry. Through proper shaping of the characteristics of the external circuitry, compensation for feed structure deficiencies over a range of frequencies can be made thereby increasing the operating bandwidth of the bicone for combined feed structure operation. In addition, the external circuitry is not limited to operating performance enhancement. For special applications, it may be desirable to receive only one polarization over a certain band. This is accomplished by placing two bandstop filters between quadrature hybrids in the feed line associated with the particular polarization. Out-of-band frequencies are passed while in-band frequencies are reflected to a load.

Even more sophisticated processing is possible with this arrangement. The characteristics of the external circuitry can be made time variable as well as frequency variable. Devices such as pin diodes and varactors can be employed to vary the characteristics as desired. The antenna can be adjusted for vertical, slant or

right or left hand polarization on command. This facility is useful in identifying the polarization of received signals and can also be used in coding a transmitted signal. This flexibility can be achieved almost instantaneously. It would be virtually impossible to obtain this performance with fixed polarizers.

Further, the separate feed outputs are not restricted to being combined in a power divider 9, but are capable of being used separately or being partially coupled. The two feed lines in FIG. 5 ideally represent two separate antennas, one vertically polarized and the other horizontally polarized. Each can be directed to separate receivers or transmitters or other processing circuitry. The dual use of a single antenna optimizes the use of available antenna area, an important factor in airborne and military applications.

The components described as being contained in the external processing circuitry can be contained within the bicone antenna. The interconnecting configuration used to connect the feed structures can perform matching and amplitude or phase shaping functions over a frequency range. The application of microcircuitry permits the location of pin and varactor diodes as well as small filter networks within the bicone throat area when necessary.

In many practical cases the complexity and interaction of the feed structure and the bicone causes the design approach to include a certain degree of experimental verification. A myriad of structural variations on the basic concept of the present invention can thus be generated. While a limited number of embodiments have been disclosed herein for purposes of illustration, it will be apparent that many variations can be made therein, all without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. Apparatus for actively feeding a single biconical antenna of the type having an upper and a lower cone, the apices of which are in close proximity comprising vertical feed means for exciting the antenna in a first mode and horizontal feed means for exciting the antenna in a second mode, said vertical feed means and said horizontal feed means each being situated in the vicinity of the apices of said cones, means for transmitting signals to and from said vertical feed means and said horizontal feed means respectively, said first and second modes interacting to permit the transduction of polarized waves of substantially all orientations by said antenna.

2. The apparatus according to claim 1 wherein said horizontal feed means comprises an actively fed horizontal loop.

3. The apparatus according to claim 1 wherein said signal transmission means comprises a coaxial transmission line, said line being operably connected to each of said feed means.

4. The apparatus according to claim 3 wherein said

line has an inner conductor operably connected to one of said cones and an outer conductor operably connected to the other of said cones to form said vertical feed means.

5. The apparatus according to claim 4 wherein said horizontal feed apparatus is operably connected between said cones.

6. The apparatus according to claim 4 wherein said horizontal feed apparatus is operably connected between one of said cones and the conductor operably connected to said one cone.

7. The apparatus according to claim 1 wherein said signal transmission means comprises a first and a second coaxial transmission line, said first line operably connected to said vertical feed means for actively feeding same and said second line operably connected to said horizontal feed means for actively feeding same.

8. The apparatus according to claim 7 wherein said horizontal feed means comprises a horizontal loop.

9. The apparatus according to claim 8 wherein said loop has a first and a second end, said first end being operably connected to the inner conductor of said second line and said second end being operably connected to the outer conductor of said second line.

10. The apparatus according to claim 8 wherein said first transmission line has an inner conductor connected to one of said cones and an outer conductor connected to the other of said cones to form said vertical feed means.

11. Apparatus for feeding a biconical antenna of the type having an upper and a lower cone the apices of which are in close proximity comprising means for vertically feeding said antenna, a coaxial transmission line and a horizontal loop located in the vicinity of the apices of said antenna, said loop having a first and a second end, said first end operably connected to said inner conductor and said second end operably connected to said outer conductor such that said loop is actively fed by said line.

12. A method for feeding a single biconical antenna such that said antenna can be utilized with polarization of any orientation, said antenna being formed of an upper and a lower cone the apices of which are in close proximity, having a horizontal loop situated in the vicinity of the apices and being fed by a coaxial transmission line comprising the steps of:

vertically feeding said antenna through an operable connection between the inner conductor of said transmission line and one of said cones and between the outer conductor of said transmission line and the other of said cones and

horizontally feeding said antenna through an operable connection between one end of said loop and said inner conductor of said transmission line and between the other end of said loop and said outer conductor of said transmission line.

* * * * *