United States Patent [19]

DeMarco

[11] **3,757,253**

[45] **Sept. 4, 1973**

[54] **MULTICHANNEL TRANSMISSION LINE STRUCTURE**

[76] Inventor: **Vincent J. DeMarco,** 720 4th St., El Cajon, Calif. 92020

[22] Filed: **Sept. 29, 1972**

[21] Appl. No.: **293,349**

Related U.S. Application Data

[63] Substitute for Ser. No. 62,880, Aug. 11, 1970.

[52] **U.S. Cl.** .... **333/1,** 333/84 M, 333/96, 333/98 TN

[51] **Int. Cl.** **H01p 5/12,** H01p 1/06, H01p 5/12

[58] **Field of Search** .... 333/1, 84 M, 96, 333/98 TN

[56] **References Cited**

UNITED STATES PATENTS

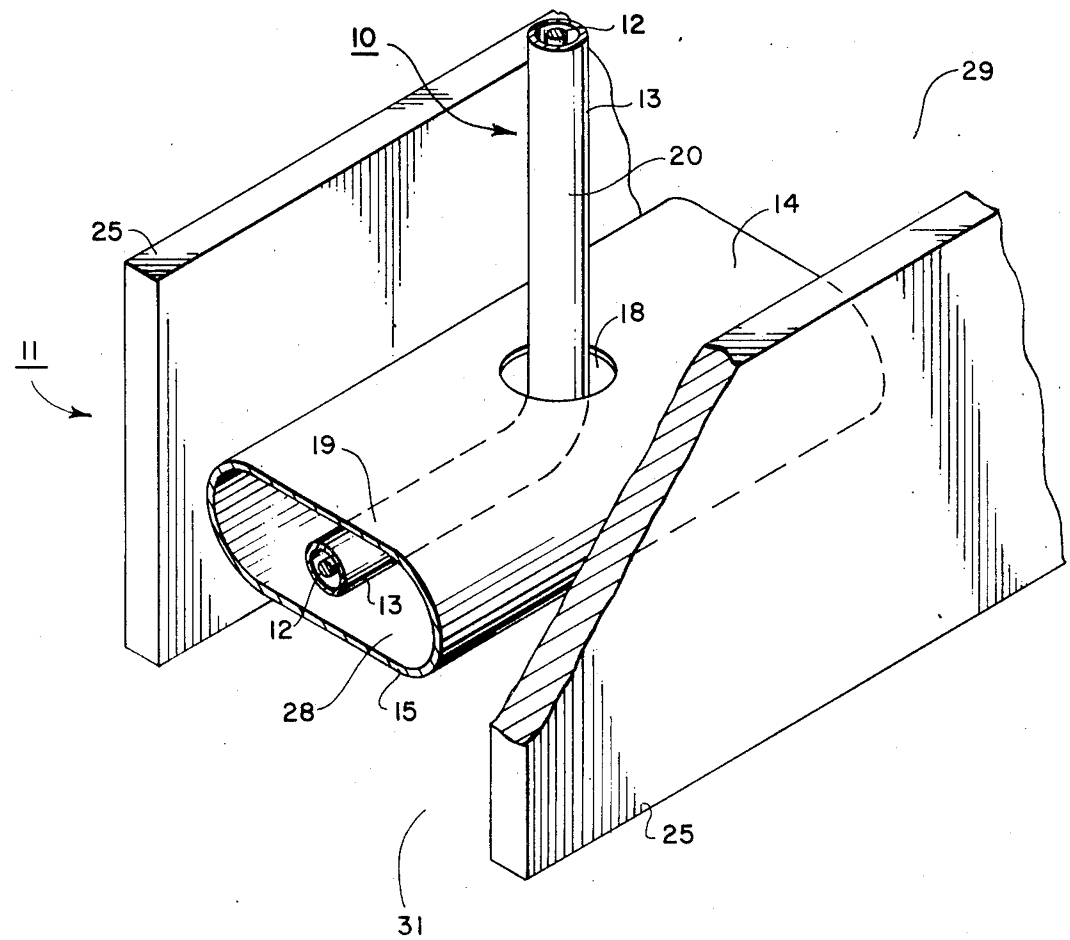
2,052,339	8/1936	Dallen Bach	333/96
2,961,623	11/1960	Kuecken et al.	333/84 M
3,500,263	3/1970	Adam et al.	333/84 M
3,621,475	11/1971	Walters	333/1

Primary Examiner—Rudolph V. Rolinec
Assistant Examiner—Wm. H. Punter

[57] **ABSTRACT**

Disclosed is a structure for providing the convergence or divergence of two independent transmission lines intersecting one another at an angle wherein, at the intersection of the two transmission lines, one of the transmission lines has a section thereof which is of slab line configuration, the center conductor of the slab line configuration having an aperture therein through which passes the other transmission line, the other transmission line having a section which is coaxially disposed within the center conductor. As a specific application, a rotary joint assembly is disclosed wherein the two rotatable sections each include the recited structure.

12 Claims, 4 Drawing Figures



PATENTED SEP 4 1973

3,757,253

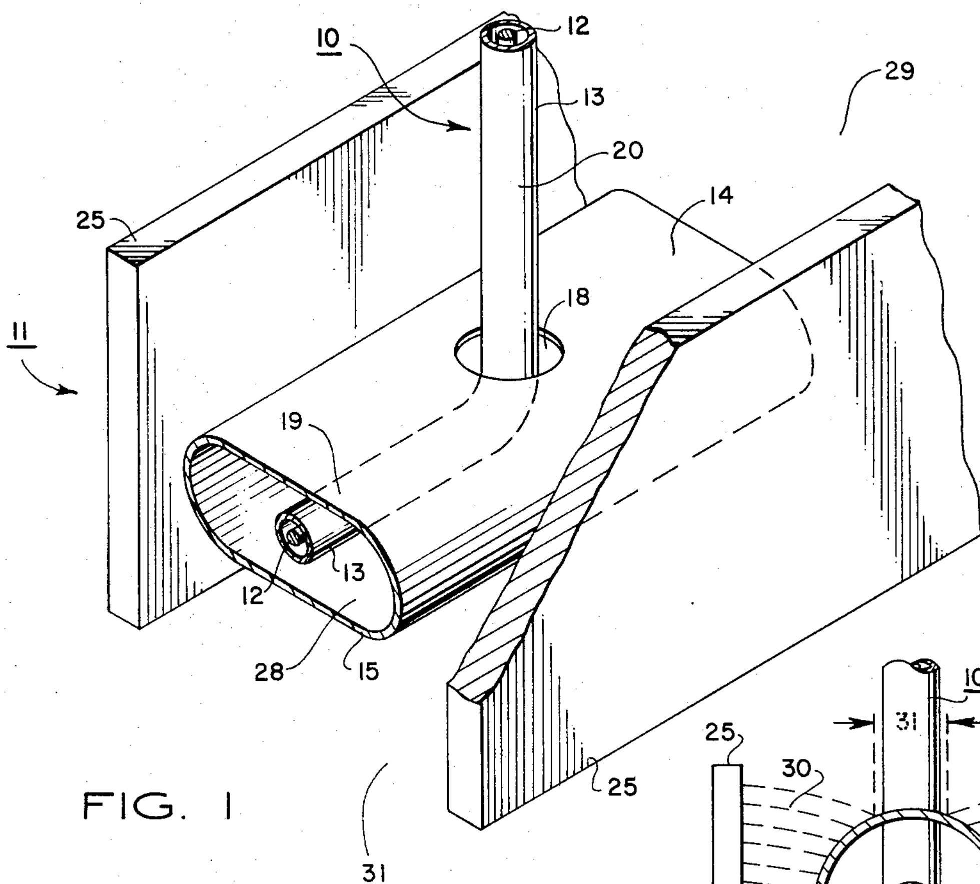


FIG. 1

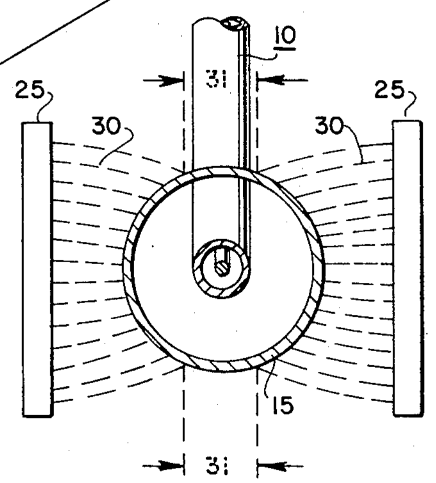


FIG. 3

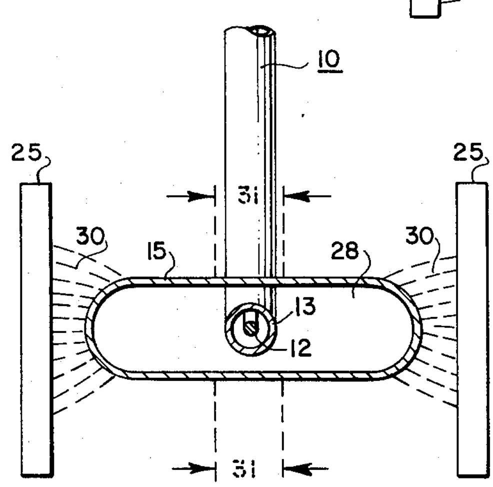


FIG. 2

INVENTOR
VINCENT J. DEMARCO

Kenneth R. Glaser
ATTORNEY

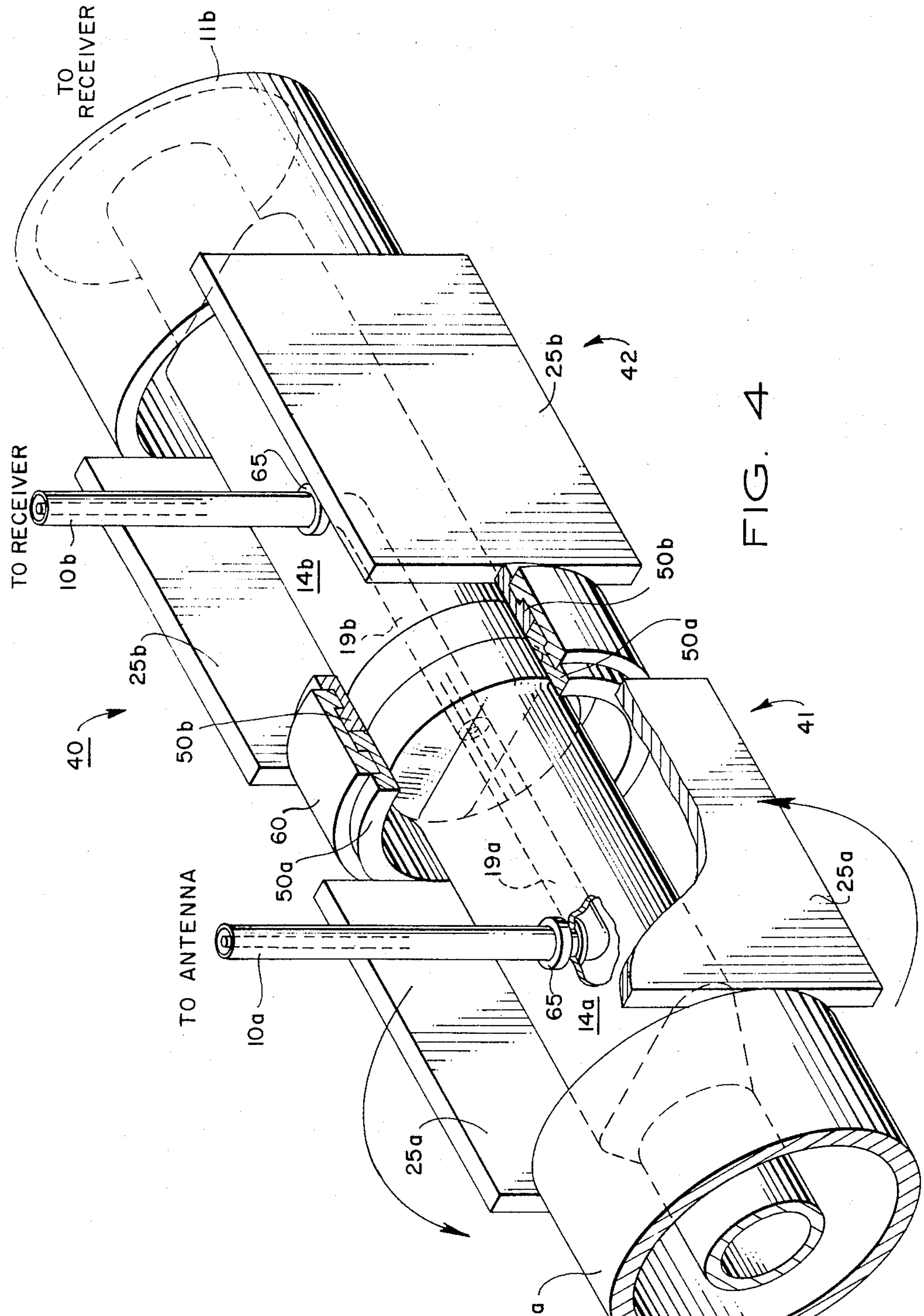


FIG. 4

INVENTOR
VINCENT J. DEMARCO

Kenneth R. Glaser
ATTORNEY

MULTICHANNEL TRANSMISSION LINE STRUCTURE

This invention pertains to the multichannel transmission of radio frequency energy, more particularly to the transmission of radio frequency energy along multiple transmission lines having converging portions thereof, and even more particularly to concentrically disposed multichannel input and output sections for feeding rotary joints.

The transmission of *r-f* energy often requires the employment of two or more transmission lines providing multichannel coupling from and to the source and receiver of the energy. In many instances, it is desirable that these multiple channels converge or intersect at specific locations for the purpose of coupling into or out of various assemblies associated with the overall system. For example, in many continuous scan antenna systems requiring rotary joint assemblies for enabling relative rotation between the transmitting or receiving antenna and the coupled transmission lines, the multiple transmission lines converge at the input and output feed sections to and from these rotary joints.

One of the conventionally known techniques for effecting the intersection of these multiple transmission lines is through quarter-wavelength right angle stub transitions. Among the disadvantages associated with this technique, however, are limitations on the operational bandwidth due to the inability to maintain, over more than a 10 percent to 15 percent bandwidth, a low ratio of the amplitude of the reflected and incident transmitted waves (or VSWR); the need for excessively long stubs at the lower frequencies due to the quarter-wavelength requirement; and power limitations due to the voltage increase at stub termination.

It is therefore a primary object of the present invention to provide a new and improved technique for enabling the convergence of two or more transmission lines in such a manner as to substantially eliminate the degradation of electrical performance as a consequence thereof;

It is a further object of the invention to provide a novel coupling arrangement for multichannel transmission lines having converging portions concentrically disposed with respect to one another;

It is an even further object of the invention to provide a new and improved design of the input and output feed sections to a rotary joint.

In accordance with these and other objects, the present invention is directed to the angular convergence (or divergence) of two independent transmission lines, whereby at the situs of intersection, one of the transmission lines has a slab line configuration, the second transmission line passing through an aperture in the center conductor of the slab transmission line at the locale of minimum electric field. In accordance with a specific feature of the invention, a portion of the second transmission line is disposed within the confines of, and is concentrically disposed with, the center conductor of the slab line to enable straight forward "in line" coupling to the external structure.

These and other features, as well as additional objects and advantages, of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a pictorial view of the situs of intersection of two transmission lines in accordance with the design of the invention;

FIG. 2 is an end view of the structure illustrated in FIG. 1 showing the electric field distribution thereof;

FIG. 3 is an end view illustrating an alternate embodiment of the center conductor of the structure illustrated in FIG. 1; and

FIG. 4 is a pictorial view of a rotary joint assembly utilizing the coupling arrangement of the invention in the input and output feed sections thereof.

Referring now to FIG. 1, a pair of transmission lines **10** and **11** are illustrated at their convergence or intersection point. The transmission line **10** may be of any known configuration, but in this example is of the conventional coaxial type having a rod like center conductor **12** surrounded by an outer conductor **13** of tubular configuration. The transmission line **11** may be of any structure or form known in the art, including of coaxial construction, but in accordance with the invention, has a section of slab line configuration at the locus of its intersection with the transmission line **10**. Thus, the section of the line **11** includes a center conductor **14** having an enclosed wall portion **15** disposed between, and electrically separated from, a pair of flat and relatively wide slab type conductors **25**.

The coaxial line **10** extends through an aperture **18** formed in the wall portion **15** and, in accordance with a particular feature of the invention, has a section **19** which is coaxially disposed with the center conductor **14**, the other section **20** being angularly disposed (90° in this example) with the coaxial section **19**.

As indicated by reference to FIG. 2 (and FIG. 3), as a consequence of the slab line configuration, the concentration of the electric field lines **30** between each of the slab conductors **25** and the center conductor **14** provides a pair of regions or locales **31** in which the electric field **30** is at a minimum or substantially nonexistent. The aperture **18** in the wall portion **15** is advantageously disposed within one of these regions **31** so that the passage of the transmission line **10** through this aperture **18** and into the cavity **28** defined by the wall **15** does not disturb or interfere with the concentrated electric field, thereby avoiding any degradation of the electrical performance due to the convergence of these two transmission lines **10** and **11**.

Consistent with the teachings of the invention, the outer wall **15** of the center conductor **14** may be formed in various alternative shapes or profiles (squares, circles, ellipses, etc.) so long as there is a cavity portion **28** defined thereby through which the section **19** of the line **10** may extend. For instance in one extreme, as illustrated by FIG. **3**, the center conductor is circular. As a particular feature of the design of the invention, however, the top and bottom surfaces of the wall **15** are elongated with respect to the side portions to provide a somewhat elliptical structure illustrated in FIGS. **1** and **2**, the maximum strength field lines **30** thereby being further spaced from the aperture **18**. In this manner, additional decoupling is accomplished between the transmission lines **10** and **11**.

The coupling structure illustrated in FIG. **1** may be utilized in many applications whereby two or more angularly disposed transmission lines are to converge so as to be concentrically disposed with one another. Thus, for example, the far end **29** of the transmission line **11** illustrated in FIG. **1**, as well as the portion **20** of the transmission line **10**, may be respectively coupled to input sources of *r-f* energy. The near end **31** of the slab transmission line **11** and the portion **19** of the transmission line **10** then provide respective concentrically disposed radiation sources (antennas).

The concentric or coaxial arrangement of these lines of the situs of intersection also provides a technique for the in line coupling into and out of a rotary joint. Thus, and with reference now to FIG. **4**, a rotary joint **40** is illustrated by comprising an input section **41** and an output section **42**, each section utilizing the configuration illustrated in FIG. **1**.

Accordingly, a pair of transmission lines **10***a* and **11***a* provide a dual channel input from a receiving antenna system, and transmission lines **10***b* and **11***b* provide a dual channel output to the receiver circuitry. As previously described, the transmission line **11***a* (which initially may be standard coaxial configuration) takes on a slab line configuration at the input section **41** comprising elliptical center conductor **14***a* and outer conductor slabs **25***a*. Similarly, transmission line **11***b* takes on a slab line configuration at the output section **42** comprising elliptical center conductor **14***b* and outer conductor slabs **25***b*. Transmission lines **10***a* and **10***b* extend through the openings provided in the center conductors **14***a* and **14***b*, respectively, to provide horizontal extending portions **19***a* and **19***b* within the confines of, and concentric with, the said center conductors.

The slabs **25***a* and **25***b* may then be connected with or take on the shape of circular members **50***a* and **50***b*, each of which provide the conventional outer conductor of a coaxial line; in other words, the transmission lines **11***a* and **11***b* again resume their original configuration outside of the locus of intersection of the multichannels.

It is thus observed that the interfacing of the sections **41** and **42** enable a straightforward in line connection between each set of concentrically disposed lines, and allows for the relative rotation of the sections with respect to one another. Accordingly, the outer conductors **50***a* and **50***b* and the inner conductors **14***a* and **14***b* of the transmission lines **11***a* and **11***b*, as well as the outer and inner conductors of the transmission line segments **19***a* and **19***b* are joined in rotatable relation with one another, the collar **60** providing the coupling means between these adjacent segments. The entire input section **41**, for example, may then be rotated (counterclockwise rotation shown in FIG. **4**) with no interruption of the *r–f* energy transmission through the rotary joint.

As a consequence of this structure, the rotary joint is operational over an extremely wide bandwidth, the only limitations upon power and frequency capability being the size of the coaxial transmission lines. In one particular example, the structure illustrated in FIG. **4** was utilized in conjunction with a frequency range of transmitted signals from approximately 1 to 12 GHz, and the VSWR varied over this range from a minimum of 1.15:1 to a maximum of 1.40:1.

Various modifications of the disclosed embodiments may be effected in accordance with the invention. For example, further enhancement of the decoupling between the intersecting channels may be achieved by filling the aperture **18** with a material which is "lossy" at radio frequencies. This is illustrated in FIG. **4** wherein plugs **65** surround the lines **10***a* and **10***b* where these lines enter or exit the center conductors **14***a* and **14***b*. Some examples of suitable materials for these plugs are iron-loaded ceramic, carbon-loaded ceramic, and carbon-loaded epoxy.

In addition, while the slab conductors **15**, center conductor **14**, and coaxial cable sections **19** and **20** are illustrated as being respectively structurally separated from one another, it is only necessary that they be electrically isolated from one another. Consequently, it may be desirable to connect all of these structures with dielectric material providing the necessary electrical isolation.

In the same manner that two channels **10** and **11** are coupled, additional channels may be added in tandem to channel **10**, for instance, by utilizing other slab line configurations at the locus of intersection. Furthermore, it is to be noted that while the slab line configuration contemplates the use of two slabs **25**, use may be also had of only one slab outer conductor.

Various other modifications to the disclosed embodiments, as well as other embodiments, may become apparent to those skilled in the art without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. Multichannel transmission line structure, comprising:

a. a first transmission line,
b. a second transmission line intersecting said first transmission line, said second transmission line having a section thereof at the locus of said intersection comprising at least one slab outer conductor and a center conductor spaced, and electrically isolated, from said at least one slab, said center conductor including an enclosing wall portion,
c. an aperture in said enclosing wall portion,
d. said first transmission line extending through said aperture into the region defined by said enclosing wall portion.

2. The structure as defined by claim **1** wherein said aperture is disposed in a region of minimum electric field established between said center conductor and said at least one slab.

3. The structure as defined by claim **2** wherein said center conductor is disposed intermediate two elongated slabs.

4. The structure as defined by claim **2** wherein said first transmission line includes a section coaxially disposed with respect to said center conductor.

5. The structure as defined by claim **3** wherein said enclosing wall portion is generally elliptical in shape.

6. The structure as defined by claim **5** wherein the intersection of said first transmission line with said second transmission line is at a 90° angle.

7. Radio frequency transmission line structure, comprising:

a. a first coaxial transmission line intersecting a second transmission line at an angular disposition thereof,
b. said second transmission line including a portion at the situs of said intersection comprising a hollow center conductor having an enclosing wall portion, a pair of slab outer conductors spaced from said center conductor, whereby concentrated electric field lines are established between said center conductor and said pair of slabs, and an aperture in said enclosing wall portion disposed within an area of minimum electric field,

c. said first coaxial transmission line extending through said aperture and including a portion thereof extending coaxial said center conductor within the cavity defined by said enclosing wall portion.

8. The structure defined in claim 7 wherein said angular disposition is a 90° angle.

9. The structure as defined in claim 8 wherein said enclosing wall portion is generally elliptical in shape.

10. The structure as defined in claim 9 including a plug of lossy material disposed in said aperture around said first transmission line.

11. Rotary joint structure for coupling transmission lines, comprising:

a. an input and output section mechanically coupled in rotatable relationship,

b. each of said sections comprising a first coaxial transmission line intersecting a second transmission line at an angular disposition thereof; said second transmission line including a portion at the situs of said intersection comprising a hollow center conductor having an enclosing wall portion, a pair of slab outer conductors spaced from said cen-

ter conductor, whereby concentrated electric field lines are established between said center conductor and said pair of slabs, and an aperture in said enclosing wall portion disposed within an area of minimum electric field; said first coaxial transmission line extending through said aperture and including a portion thereof extending coaxial said center conductor within the cavity defined by said enclosing wall portion; and

c. means respectively coupling the first and second transmission lines of one of said sections to a source of radio frequency signals, and means coupling said first and second transmission lines of the other section to a receiver.

12. The structure as defined in claim 11 wherein the extending portion of said first coaxial transmission line of said first section is coupled to said extending portion of said first coaxial transmission line of said second section, and wherein said center conductor of said second transmission line of said first section is directly coupled to the center conductor of said second transmission line of said second section.

* * * * *